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NEW YORK, NOVEMBER, 1890.

OWING to the pressing engagements of the Author in connection with the meetings of the Institute of Mining Engineers and the Iron & Steel Institute, the regular installment of Practical Railroad Information is this month omitted. In its place there will be found the paper read by Dr. Dudley before the British Iron & Steel Institute at its New York meeting, on the Wear of Metal as Influenced by its Chemical and Physical Properties; a paper which is in itself a valuable contribution to practical knowledge, and so finds an appropriate place in our series, though it comes a little out of its due course.

THE remains of Captain John Ericsson, which were carried to Sweden by the cruiser *Baltimore*, were received in that country with appropriate honors, and have found their final resting-place in the graveyard at Filipstad, in the province of Wermland, close to the spot where the great engineer was born. The coffin is deposited in a mortuary chapel built for the purpose.

It may be noted that the railroad over which the coffin was carried from Stockholm to Filipstad was located and built under the direction of his brother, Nils Ericsson, who held high rank in Sweden as a civil engineer.

LATEST advices from China are that the Viceroy Li Hung Chang has completed arrangements for the extension of the Tientsin-Kaiping Railroad to Kisin. The immediate object of the new line is rather military than commercial.

There is in China a growing fear of Russia, especially in view of the probable early construction of the Siberian Railroad, which will connect the Pacific Coast settlements with European Russia.

The new Chinese railroad extension will run from Kaiping toward the northeast, passing through the northeastern portion of the province of Chih-li, then through the province of Sheng-Ching and on to Kisin, which is the capital of the province of the same name, bordering on Siberia.

The exact course of the road is not yet known, but it will probably pass through Shan-hai-Kuan, Niu-chuang and Moukden. It is expected that the road will be unprofitable for some years, but as it will pass through a very fertile but now sparsely populated region, it will prove profitable in the end by developing the provinces of Sheng-ching and Kisin.

The funds for the new enterprise have been borrowed from European capitalists, a loan of 20,000,000 taels at 4½ per cent. interest having recently been negotiated.

THE production of pig iron in the United States for the year ending June 30, 1890, according to the statistics collected by the Census Office, was 9,579,779 tons (of 2,000 lbs.); an increase of 153 per cent. over the census year 1880. Iron was produced in 24 States, and the changes in different sections are well shown by the following table, taken from the preliminary report:

DISTRICTS.	Year Ended May 31, 1870.	Year Ended May 31, 1880.	Year Ended June 30, 1890.
New England States.. ..	34,471	30,957	33,781
Middle States............	1,311,649	2,401,093	5,216,591
Southern States....	184,540	350,436	1,780,909
Western States...........	522,161	995,335	2,522,351
Far Western States......	....	3,200	26,147
Total	2,052,821	3,781,021	9,579,779

The most remarkable growth here shown is in the South, where the development of the iron industry has been rapid during late years. Thus Alabama, which is now the third iron producing State, was tenth in 1880, while Virginia has risen from seventeenth to sixth.

As to fuel, the comparative statements show a small increase in charcoal furnaces, and a considerable decrease in those using anthracite coal, the great gain in production being made by the furnaces using bituminous coal and coke. It may be noted that in 1890 nearly 44 per cent. of the whole production was Bessemer pig iron.

The change in methods is well shown by the fact that while the increase in pig-iron production in 10 years was 153 per cent., the number of furnaces in 1890 was 562, against 681 in 1880—a decrease of 17½ per cent. This is due to the abandonment of many of the old furnaces, which have been replaced by larger ones; expressed in another way, the average output per furnace (counting all completed) has risen from 5,552 to 17,046 tons a year—the average furnace of 1890 has over three times the capacity of that of 1880. This, however, is not at all exact, since probably a larger proportion of furnaces were in blast last year; but it is an approximation, and shows the change that has taken place.

THE question of the building of the Quaker Bridge Dam has been reopened by a report recently submitted to the New York Aqueduct Board by Chief Engineer Fteley. In this report he states that careful investigations have been made with regard to the underground formation of the Croton Valley above and below the location recommended for the Quaker Bridge Dam, the general result being to show that the rock underlying the valley forms a deep trough, the bottom of which is from 60 to 108 ft. below the river bed. This trough is filled with drift composed of hard-pan and boulders, with here and there compact sand. While additional storage is undoubtedly needed, and there is at present a great waste of water which runs over the

old Croton Dam in rainy seasons, Mr. Fteley is, in light of all the facts collected, not prepared to recommend the building of a dam on the site recommended by the engineers at Quaker Bridge. Two alternative propositions are submitted in the report, the first being for the building of a dam at Cornell's, 1¼ miles above Quaker Bridge, which would be about 1,736 ft. long, and where the rock is at considerably less depth than at Quaker Bridge. The second point indicated is designated as "Location 2," a little less than a mile below the Croton Dam. Here the length of the dam required would be only 995 ft., and the height above the river 100 ft. The size and location of the dam needed at this point is such that it could be in part an earth embankment, and while the storage capacity of the reservoir formed by its construction would be somewhat less than half that of the Quaker Bridge Reservoir—16,000,000,000 galls. against 34,000,000,000—the cost would be considerably less than half. It is thought that the storage capacity would be ample for the needs of the city for at least the next 20 years; probably for a much longer period when it is supplemented by the building of the proposed new reservoirs in the water-shed of the Upper Croton.

To sum up the reasons for recommending a dam at the new site, they are that it can be built in much less time, say three years instead of six; the land to be taken is of much less area: the necessity of building two costly bridges and several new roads is avoided; the dam being of less height, risks of accident and delay would be much less, and finally the cost would be much smaller.

With the construction of this proposed dam the total storage available, including the present reservoirs and those under construction, would be over 50,000,000,000 galls., or more than 200 days' supply for the city.

A STRIKING paper on the Protection of Iron and Steel Ships was read at the Pittsburgh meeting of the Iron & Steel Institute by Sir Nathaniel Barnaby, an eminent authority on shipbuilding in England. While finding much fault with present systems of construction for their imperfection, he claims that size is in itself an element of safety, and he believes that in the future the mastery of the seas will be gained by the building of ships of far greater dimensions than any which we have yet reached. Such a ship, say 1,000 ft. in length and perhaps 300 ft. in breadth, with engines of at least 60,000 H.P., would be practicable, and could be made almost absolutely secure against ordinary marine disaster, and Sir Nathaniel believes that it might be constructed before many years had passed, startling as the idea may now seem to us.

THE plans for the three new battle-ships have been somewhat modified by the Navy Department. The principal change is an increase of 16 ft. in the length and of nearly 700 tons in displacement, so that these vessels will be 348 ft. in length and 10,000 tons displacement with an ordinary load, which may be increased when they are carrying coal for a long cruise. It is believed that the model will be so improved that a speed of 15 knots an hour can be obtained without any material increase in engine power.

The increased displacement will be utilized in great part by putting on additional armor, extending the water-line belt, and increasing the thickness of the casemates and the shields provided for the 8-in. and 6-in. guns. The change will not alter materially, however, the general design of the ships, but will, it is believed, somewhat increase their capacity and effectiveness.

ON another page will be found the last of a series of articles on the Development of Armor in modern warfare, which are appropriately brought to a close by an account of the latest armor tests at Annapolis. This series of articles, which has included guns and armor—the methods of attack and defense above ground or above water—will be completed by an account of submarine mines and projectiles. Torpedoes are a subject about which much has been said, though but little has been done with them in actual warfare.

THE Annapolis armor trials, to which reference is made on another page, seem to establish the excellence of our naval guns, whatever conclusion may be reached as to the armor-plates. The gun shop at the Washington Navy Yard has now been developed into an establishment where work of the highest class can be not only thoroughly, but quickly done. This may be of very great importance to the country, and it is to be hoped that future appropriations will permit a proper increase of the plant and efficiency of the shop.

THERE is to be no diminution of activity in the Lake shipyards this winter. The various yards at Buffalo, Cleveland, Toledo, Detroit, Bay City and Duluth are all busy, and the contracts already placed, according to the *Marine Review*, include 29 steamships and 5 steel barges, having a total capacity of 81,600 tons. Seven of the steamers only are to be of wood; the remaining 22 will have steel hulls. Nearly all of them are large vessels, as may be seen from the total tonnage reported. Besides these other contracts are pending, which will probably bring the total up to over 100,000 tons.

THE Portage Lake Canal, originally a private enterprise, is to be sold to the Government, and will, with its connections, be widened and deepened, furnishing a channel for the largest vessels, and enabling them to avoid the detour around Keweenaw Point, the most dangerous piece of navigation on Lake Superior. The works purchased include two canals, one 5 miles in length and connecting Portage Lake with Lake Superior on the east, the other 2½ miles long and making the connection to the westward. The price to be paid by the Government is $350,000, and a considerable amount must be spent in dredging and deepening the channel through the lake.

UNDER the act passed at the last session of Congress authorizing the letting of contracts for guns for the Army, the Chief of Ordnance has called for bids for 100 new guns, 25 to be of 8 in., 50 of 10 in., and 25 of 12 in. caliber. They are to be of the types provided in the specifications, but the kind of steel and the methods of manufacture will be left to the contractors. The lengths and weights are to be: 8-in. guns, 32 calibers length of bore, weight 14½ tons; 10-in., 34 calibers, 30 tons; 12-in., 34 calibers, 52 tons. The proposals will be received until December 18. The guns will be subjected to very severe tests as to quality of metal, range, accuracy, and endurance.

TESTS of steel, and the causes of delay in delivering material for the new ships under contract, were discussed

at a conference held at the Navy Department in Washington recently, at which were present representatives of the firms now building ships for the Navy, and the firms which are supplying the steel. Some relaxation in the strictness of the tests was asked for, but no action has been taken as yet.

EVOLUTION IN THE LABOR QUESTION.

THAT the relation of laborers to their employers is in a state of evolution is indicated by a pamphlet recently issued by the managers of the New York, Lake Erie & Western Railroad. This contains a communication from the federated body of employés of that road composed of engineers, conductors, firemen, and trainmen, who say that they respectfully submit to the manager "the following schedule of pay and regulations to govern said employés, to which we expect a just and satisfactory answer, within a reasonable length of time." Then follows a schedule consisting of 83 distinct articles "to govern said employés." These relate to the rate of pay, hours of work, duties, promotion, suspension, passes, leave of absence, etc., of the employés.

To this petition the President of the Company has made a respectful reply, explaining fully why most of the requests could not be granted. A review of the reasonableness or unreasonableness of the 83 articles would occupy more space than can now be devoted to this subject, but the aspect of the case to which especial attention is called, is the calm and apparently reasonable way in which the requests of the men are presented, and the just and fair consideration which they have received. The attitude of both sides is expressed in scriptural language, "Come now, let us reason together." This certainly is very much better than that assumed by the manager of a Western railroad about twenty years ago, when waited on by a committee of the men who had "grievances" and were met by the reply that "they should go to hell." On another occasion, when a strike was defeated, a division superintendent telegraphed with great glee that "The Brotherhood of the Foot Board has been crushed." At that date the idea of "crushing" trades unions was very generally entertained. The pamphlet before us shows how much more rational the attitude now is, which the managers and the men have assumed toward each other. It should be kept in mind by both sides, however, that the basis of all this is "sweet reasonableness," and that when either side makes unjust demands, the other—to quote Scripture again—is quite sure to say, "Should a wise man utter vain knowledge and fill his belly with the east wind? Should he reason with unprofitable talk? or with speeches wherewith he can do no good?"

Some of the requisitions of the employés of the Erie system and the recollection of unreasonable demands which have from time to time been made elsewhere, lead to the suggestion that the employés would usually strengthen their cause very much if they would employ some competent and wise lawyer in formulating their demands. The presentations of the employés' side of the labor question are not usually models of English composition. A good lawyer would not only express their side of the question better than it usually is, but by his advice they would often be prevented from falling into the serious error of making claims which in their nature are unwise or which would lead to violations of the law.

The pamphlet issued by the managers of the Erie system is evidence that the idea of crushing or eradicating trades unions is, at least in some quarters, not entertained any longer, and that it is wise for both men and managers to discuss questions in dispute between them like rational human beings rather than to fight it out like savages.

BRITISH AND YANKEE LOCOMOTIVES.

THE discussion of this subject by our cisatlantic and transoceanic contemporaries seems to have reached the profane stage represented by a well-known picture of a loquacious bird and a mischievous quadruped, in which the one is plumeless and the other has been curtailed. As evidence of this, the language of the purveyor of American engineering news may be quoted. In a recent number our contemporary says: "The discussion (was) closed so far as we are concerned in our issue of September 27, . . . as it is quite useless to carry on a technical discussion with an antagonist who will not even truthfully state the positions and arguments which he is opposing."

This language is not flattering to the other disputant and is not characterized by "sweetness," nor does it indicate that the author is in a frame of mind which would be receptive of "light." Although his mental vision, so far as this subject is concerned, seems for the time to be somewhat obscured, yet from the fact that he has published the comments on this subject, which appeared in the last number of this JOURNAL, he is evidently still able to recognize a source from which light emanates. In an introductory way he says: "Our lively contemporary"—meaning us—"makes answer to one of the points raised by the *Engineer*, which is so apt and to the point, and withal so amusing, that we cannot forbear quoting it." We regret that it is impracticable to print this page on pink paper, to be indicative of how such complimentary language effects our complexion.

In his introductory remarks to the reprint, of what first appeared in these columns, he puts in a sort of claim for priority by adding "that we perceived *this* to be one of several points in which our English contemporary's positions were very vulnerable, as will appear from a quotation given below." It is not easy to tell what "*this*" refers to. The only construction that can be put on the language is that by "this" is meant "one of the points raised by the *Engineer*," the weakness of which was pointed out in the article which the *News* reprints. Before doing so the editor takes occasion, however, to remark that "we perceived this," but considered it "quite useless" to say so. There are occasions which arise in discussions of this kind, when the only comment which can be made is expressed by an exclamation mark. This seems to be such an occasion.

The use of exclamation marks is also demanded on reading his comments on the article which our contemporary has republished. He says that "we distrust our lively contemporary's figures above, in so far as they appear to show higher evaporations than some 700 lbs. per square foot of grate, a certain error resulting from the assumptions made in regard to average speed, probably." Then follows an extract from a book which the editor of the *News* is the author of, in which the dictum is expressed that "ordinarily it is not possible to evaporate more than 600 lbs. of water per square foot of grate per hour,

. . . and 500 lbs. of water per square foot of grate would come nearer to a moderate working maximum."

We confess our inability to comprehend the nature of a "certain error" which is "probable" or of a "moderate maximum," and will leave the subtle author of the book quoted from to struggle with the metaphysical distinction involved in such expressions, but when he speaks of "assumptions in regard to speed" a total and absolute denial is the only reply to be made. Such "assumptions" are the result of his imagination. There were none. The speeds given in our article were taken by careful observers and were given on the authority of the Superintendent of Machinery of the Grand Trunk, the Baltimore & Ohio, and the New York Central & Hudson River Railroads.

Furthermore, the context where the assumed error in regard to speed is pointed out, and the writer's quotation from his book is given is suggestive. What is said is in effect "we distrust our lively contemporary's figures." In my book it is written differently. Surely "lively" is not the adjective which would properly describe a state of mind capable of producing such a potential syllogism—*viscid* would be better.

The discussion and the conclusions reached by the disputant on the other side of this discussion, in which we occupy the position of a commentator, may be briefly summed up. Some time ago the *Engineer* said that "the whole discussion turns on whether a locomotive boiler has to generate more steam in a given time in America than in England." In an article on Mr. Barrus's tests of Vauclain's compound locomotive, built at the Baldwin Locomotive Works, which article was published in the *Engineer* of September 19, the Editor of that paper says: "The running time (of the Vauclain engine) was six hours, and in that time there was burned 16,389 lbs. of coal. As the grate area was 25 square feet, a very simple calculation shows that the rate of combustion per square foot of grate per hour was over 109 lbs. *We have nothing in England to equal this. About 75 lbs. per square foot of grate per hour may be regarded as a maximum consumption with our fastest and heaviest expresses.*" In our article, already referred to, it was shown that on the Hudson River Railroad during 66 runs of 143 miles each 119.6 lbs. of coal was burned per square foot of grate per hour. On the Grand Trunk 121.6 lbs. and on the Baltimore & Ohio in one case in a test of an hour's duration on their 17 mile grade, they burned 133.2 lbs., in another 148.1, and *in a third* 193.7 *lbs. of coal per square foot per hour.* The experiments on the latter road were made by the present Superintendent of Machinery of that line, and are vouched for by him. It is not easy to emphasize this evidence sufficiently. If we can burn more than twice as much coal in our locomotives as can be burned on those built in England, we are in a position to proclaim the fact to the world. Our builders can now say to railroad companies in Australia, in India, in South America, and, in fact, everywhere, that they can furnish locomotives which will do nearly or quite twice as much work as is done by English engines of like weight. The admissions of the *Engineer* and the evidence submitted by THE RAILROAD AND ENGINEERING JOURNAL now seem to make this certain.

In the beginning of this article we ventured to intimate that some of the feathers of one of the disputants in this controversy were missing, and the posterior ornament of the other had been lessened. As we occupy the position of a commentator only, neither party is obliged to reply to our comments, but if, with the evidence which has been submitted, our English contemporary remains silent about it, there will be additional grounds for the conclusion that so far as the capacity for burning coal and generating steam is concerned, the superiority of American locomotive boilers has been proved, and that our simile of the parrot and that "amoosing little cuss," as Artemus Ward described the other figure in the picture referred to, has not been misapplied. Regarding the question whether under like circumstances, or with moderate train loads, and the same quality of coal, English engines would be more economical than ours, no evidence has been submitted. It is to be regretted that the feelings, as well as the feathers, of one of the disputants in this controversy have been so ruffled as to lead him to declare that, "so far as they are concerned," they won't play any longer. There are still many questions in dispute which have not been touched and which interest engineers the world over. The discussion has not only been amusing, but it has educed the important fact that American locomotives can and do burn a great deal more coal and generate more steam in a given time than English engines can or do. This fact has never been brought out so clearly before. In view of this it is to be regretted that our American contemporary has allowed his angry passions to rise, because if the discussion was continued and a little side light was thrown on it by independent commentators, it might be equally productive in other directions. Besides, we hoped that both parties to the controversy might be induced to adopt our suggestion, and each design a locomotive for comparison and criticism. If they did then the discussion would certainly be entertaining.

WORLD-RAILROADS.

SOME interest was taken a few months ago in certain trips around the world, undertaken to show in how short a time the journey could be accomplished. The time actually made by existing railroad and steamship lines was 73 days; and this could be reduced by three or four days under favorable circumstances and with prompt connections.

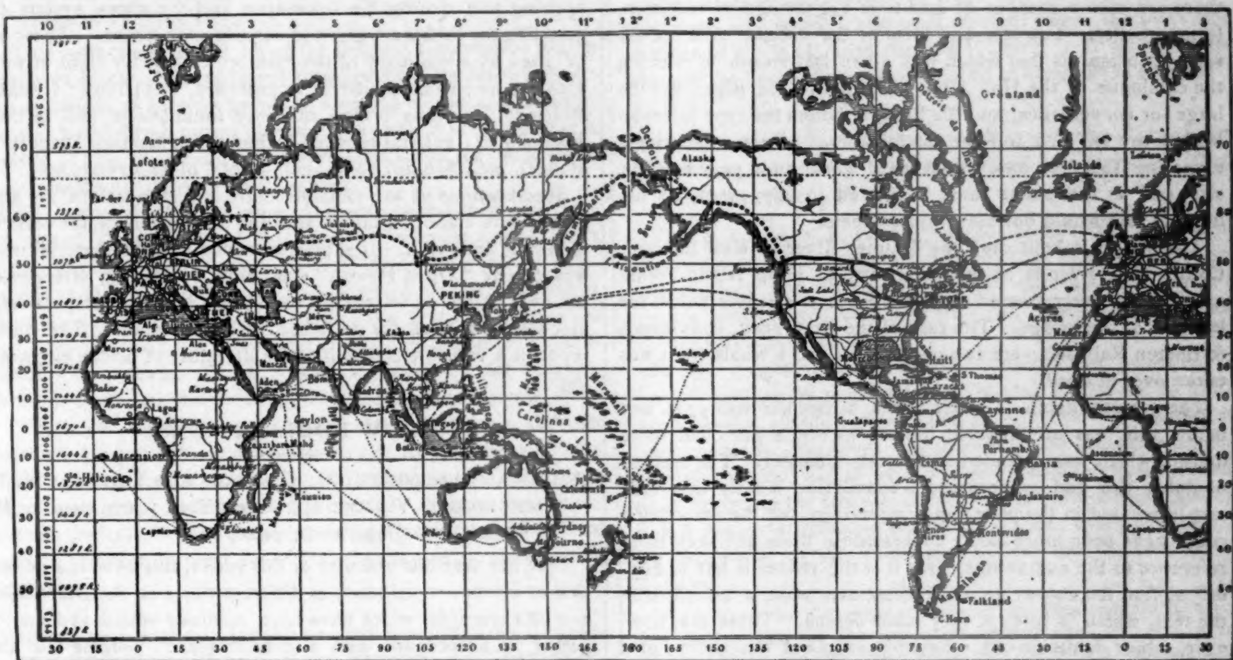
Taking these voyages as a text, M. Weissenbruch, Engineer to the Belgian Ministry of Railroads, in a recent note published in the *Bulletin* of the International Railroad Congress, shows how this time may be diminished, and also how it is within the limits of possibility, and is even probable, that within a few years the traveler will be able to make the journey from London to New York by rail.

Three great transcontinental lines—or, as the Germans would call them, world-railroads—are projected in Asia. The first of these is the line from Constantinople to Bagdad, and thence by way of the Tigris Valley, the Persian Gulf, and through Belouchistan to a connection with the Indian Railroad system on the Upper Indus. While a beginning has actually been made on this, actual work has been limited to some 90 miles, from Scutari to Ada-Bazar, in Asiatic Turkey, and it is not likely to advance very rapidly until economic conditions in Turkey are materially changed, and English capital can be largely drawn in that direction.

The second is the so-called Grand Central Asiatic line,

proposed by M. Cottard, a French engineer, and M. de Lesseps. This would start from Orenbourg, in Russia, run through Western Siberia and Tartary to a connection with the Trans-Caspian line at Tashkend, and thence by Samarkand and Kabul to Peshawur, in Upper India. This is purely a paper project, with no present prospect of construction, and is interesting only as a remote possibility.

The third line is the Great Siberian Railroad, of which some account has already been given in our columns ;* and this is the only one of the three which can be said to be under actual construction. The first and most difficult sections are well advanced toward completion, and there is little doubt that when the great plains of Southern Siberia are reached, it will be pushed forward steadily ; perhaps even there may be a repetition of the extraordinary work which called such wide attention to the building of the Trans-Caspian Railroad, under General Annenkoff.



The objective point of the Siberian Railroad is Vladivostok, which is only 920 nautical miles from Yokohama ; and it will readily be seen how much its completion will shorten the time required to circumnavigate—if that term can properly be used for a journey made half by rail—the globe.

But the Siberian Railroad is destined, M. Weissenbruch thinks, to have two great branches. The first will pass through Kiahkta into China, and in time to Pekin ; but this, while commercially of great importance, will not be part of the world-railroad. The greater branch will start from Nertschinsk or Albasin, on the Amoor River, and will run northeastward, skirting the Okotsk Sea, and crossing Kamchatka to Behring's Straits ; there to meet what, for want of another name, we might call the Alaska Central & Atlantic line, which would run from Behring's Straits southward to a connection with the Canadian Pacific at Vancouver, and with the Northern and the Southern Pacific at Tacoma and Portland.

The bridging of Behring's Straits presents no serious obstacles ; nor would it be more difficult to run a railroad in Kamchatka and Alaska than in the north of Sweden or in some parts of Russia, where lines are already worked successfully.

The possibilities may be extended indefinitely ; the International line, connecting North and South America, may be completed, and in that case the traveler might take his "through sleeper" in London, Paris or St. Petersburg, not only for New York, but for the City of Mexico, Rio de Janeiro, Valparaiso, or Buenos Ayres.

Further, it has been proposed to build a railroad from Quebec to Bay St. Charles, on the coast of Labrador, the nearest point on the American Continent to Europe, from which steamers could make the voyage to Liverpool inside of 4 days. Supposing an average speed on the railroads of 40 miles an hour—which is not impossible—the trip around the world could then be made in 23 days.

The accompanying sketch map, although on a very small scale, will be sufficient to show M. Weissenbruch's idea of the route. As to the time which it will take to realize this idea, he can best speak for himself as follows :

> But, it will be said, how much time will be required before all these works can be accomplished ?
>
> The railroad system of the world has to-day a total length of about 606,000 km. (376,568 miles), and its average increase—very slightly variable for the last period of 10 years—may be taken at 24,000 km. (14,913 miles) a year.
>
> Now to connect London and New York by rail it is necessary to build only 15,800 km. (9,818 miles) of road, an amount much less than this yearly increase.
>
> Supposing only the building of 1,000 km. (620 miles) of the road yearly ; in 15 years the projects of which we have spoken will be accomplished facts, or on the point of becoming so.

All this may seem visionary now ; but in view of the wonderful developments which many of us, who are not old men yet, have seen with our own eyes, who will venture to say that in 15 or 20 years from now the starting of the "through St. Petersburg, Paris and London express" from New York will seem a less wonderful event than the departure of a through train for San Francisco did less than 25 years ago ; or that we will not start on the rail journey of 16,200 miles to London with fewer misgivings

* See the RAILROAD AND ENGINEERING JOURNAL for June, 1890, page 258 ; for September, 1890, page 403, and in the present number, page 503.

than our fathers felt less than 60 years ago, when they entered the cars for a trip from New York to Philadelphia.

THE THAMES RIVER BRIDGE.

Report to the General Manager of the New York, Providence & Boston Railroad upon the Construction of the Thames River Bridge and Approaches at New London, Conn. By Alfred P. Boller, Chief Engineer, New York.

The title of this volume indicates its general character, but to give an idea of its form and scope some description is needed. It may be classed as a pamphlet of 60 pages, $10\frac{1}{2} \times 14$ in. in size with 13 folded plates and tables. The printing and paper are all that could be desired. Besides the lithographed plates there are also a number of half-tone engravings of rather inferior quality. The size and form of the volume calls for the same criticism as that which was given last month in noticing the catalogue of the Hall Signal Company—the pages are too large for convenience, and the lines, although the type is treble-leaded, are too long to read comfortably. All the engravings, excepting the first one, would have gone on a page half the size, and as the plates must be folded in any event, an additional fold would not have injured them.

The bridge is built over the Thames River at New London, Conn. The river is in reality an arm of Long Island Sound and was formerly crossed by a ferry some distance below the location of the bridge. The cars of the New York, Providence & Boston Railroad were run on the boat and a whole train was taken over at once.

The greatest depth of water at the bridge site was 57 ft. and below this was an unstable bottom in which piles had to be driven, which was attended with much difficulty. The method of doing this and constructing a foundation is fully described and illustrated in the plates and engravings, but the description could have been more easily understood if there had been more reference to the engravings. As it is the reader is left to himself to find the engraving which illustrates what is described in the text, which is often a very blind search. These are, however, minor faults in an otherwise excellent description of a great work.

The history and location of the bridge are fully described in the first pages. Then follows an account of the method of constructing the foundations, and the special difficulties which were encountered and the way they were overcome. Next a description of the masonry follows and of the settlement of the piers.

The bridge itself consists of a central draw of 503 ft. span measured from center to center of outside piers. There are then two through spans, symmetrically disposed one on each side of the draw-span. These consist of two trusses on the Whipple system 45 ft. deep at center for three panel lengths, thence sloping downward on either side at the rate of 5 ft. to the panel to the end posts, where the trusses are 25 ft. deep, a form of construction conducive to economy by reducing the sheer in the web system, to say nothing of a more sightly appearance than would result from trusses of a uniform depth throughout. Outside of each of the through spans is a deck span 20 ft. deep and designed on the triangular system, and composed of five panels 24 ft. 8 in. long with intermediate posts supporting the upper chords.

The swing-span, with the same depth of truss at the ends as the adjacent fixed spans, slopes upward toward the center, where it attains a height of 71 ft., two-fifths the slope on either side of center being in a parabolic curve, the balance being a straight incline. This symmetrical disposition of the trusses and their form, especially that of the draw-span, gives the bridge a peculiarly graceful appearance. The æsthetic features of the structure have evidently been studied, as well as its purely engineering features. It is gratifying to know that the design is not only graceful and pleasing, but that it is also economical. The excuse for making structures hideous and unsightly is that it would be too expensive to make them otherwise. As a matter of fact the ugliness of bridges is due generally to the absence of a sense of beauty or grace in their designers. In the present instance the Engineer of the Thames River Bridge was an artist as well, and as a result both the engineering and the artistic effects are good and neither was sacrificed for the other, and, in fact, the science of the engineer seemed to improve the work of the artist, and *vice versa.*

The description of the difficulties and the methods of sinking and forming the foundation will be interesting to all engineers engaged in similar work. The illustrations of these and of the superstructure of the bridge are excellent. The mechanism for opening and closing the draw-span and the signal system for guarding the bridge are given at considerable length. These are followed by a summary of the cost, which was for right of way, $325,214.42; construction of approaches, $254,189.87; superstructure, including bridge, masonry foundations, and testing, $658,489.50; general account, including engineering, inspection of steel, etc., $56,046.12, making a total of $1,293,939.90.

Specifications of the superstructure and foundations are also given, with elaborate tables showing the results of the tests of materials are given. It should be added that the material used was chiefly "Open Hearth" steel with a breaking strength of not over 65,000 or 68,000 lbs. per square inch, but some Bessemer steel was used for the compressive members. The whole report is a valuable addition to the literature of bridge engineering.

NEW PUBLICATIONS.

PRACTICAL BLACKSMITHING: COMPILED AND EDITED BY M. T. RICHARDSON. VOLUME III. New York; published by M. T. Richardson (illustrated; price, $1).

Like the previous volumes of this series, this book is a collection of articles contributed at different times to the *Blacksmith and Wheelwright,* which have been carefully edited and put together in accordance with a definite plan. Volume I of the series dealt chiefly with shop plans, forges and chimneys, with some articles on the early history of blacksmithing. Volume II treated of tools, while Volume III, the present one, finishes the subject of tools and then goes on to describe methods of doing a great variety of the jobs which are likely to come to the blacksmith in the course of his every-day experience. The chapters under the latter heading include Welding; Steel and its Uses; Forging Iron; Chain Swivels and Plow Work.

Under each of these headings we find a number of notes. For instance, in the chapter on Forging Iron there are given several methods of forging a valve-yoke; several for making eye-bolts, T-irons and a variety of wagon and locomotive work. All these are illustrated, and the directions are generally practical and to the point.

The articles generally have been written by practical men, and describe methods of work approved by experience. The book, while not an exhaustive treatise on metal work, contains much that is of practical use, and a blacksmith can hardly read it without getting information which should be of value to him in his work.

A fourth volume is promised, which will complete the series.

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION, HELD AT OLD POINT COMFORT, VA., JUNE 17, 18 AND 19, 1890: EDITED BY ANGUS SINCLAIR, SECRETARY. New York; published for the Association.

The Report of the Master Mechanics' Association has been brought out this year by Secretary Sinclair with his usual

promptness. It covers a convention of somewhat more than usual interest, in which some points of importance were discussed. Perhaps the portions which will be most read and referred to will be the reports and discussions on Compound Locomotives and on the Link and other Valve Motions. The action taken which will interest many members is the appointment of a committee to arrange for bringing the yearly convention and that of the Master Car Builders' Association closer together. A new subject appears in the appointment of a committee to report next year on Electrical Appliances bearing on locomotive construction and management—a field which will probably continue to widen with each succeeding year.

A YEAR'S NAVAL PROGRESS: ANNUAL OF THE OFFICE OF NAVAL INTELLIGENCE. JUNE, 1890. Washington; Government Printing Office.

This publication is No. IX of the General Information Series prepared by the Office of Naval Intelligence in the Navy Department, and is, as its title purports, a record of the year's progress in naval development abroad. The object is to preserve a record of this progress for future reference and for the present information of our own naval officers.

The range of subjects covered is shown by the following list: Ships and Torpedo-boats; Machinery; Ordnance and Armor; Applications of Electricity; Naval Manœuvres of 1889; Ministries of Marine and *Personnel* of European Navies; Merchant Marine in Foreign Countries; Rapid-fire Guns; Liquid Fuel for Torpedo-boats; Manœuvring Distance of Steamers; Automobile Torpedoes. There is also a chapter on the development of our home resources for the production of war material.

The work has been carefully and thoroughly done, and this year's volume will bear comparison with its predecessors very well. It contains a great body of information on naval matters, intelligently arranged and presented. Special interest attaches, perhaps, to the chapters on Applications of Electricity and on Torpedoes, since those are subjects now attracting much attention.

TRUSSES AND ARCHES ANALYZED AND DISCUSSED BY GRAPHICAL METHODS. PART I, ROOF TRUSSES: BY CHARLES E. GREENE, C.E., PROFESSOR OF CIVIL ENGINEERING, UNIVERSITY OF MICHIGAN. New York; John Wiley & Sons (price, $1.25).

This is a revised edition of a book which has already met with a good reception, both as a text-book in technical schools and as a book of reference for designers. In this edition the general arrangement has been improved, and some additional problems have been added.

It is hardly necessary now to speak of the increased use and acceptance of graphical analysis for the solution of problems, or of the advantages which the graphical methods present. The book before us is a clear presentation of the problems involved in the subject of which it treats, and the simplest and most direct methods of solving them; of finding the stresses and devising methods of designing trusses for roof work.

INSTRUCTION BOOK OF THE WESTINGHOUSE AIR BRAKE COMPANY. THE QUICK ACTION AUTOMATIC BRAKE. Pittsburgh, Pa.

The above Company has just issued a very neat book of instructions concerning the use of the air brake. It is of the pocket-book form with a flap and a pocket containing four sets of engravings which show the construction of the brake, and two cards with transparent gelatine sections of the engineer's valve to show its action more clearly than it can be shown by ordinary engravings.

The Instruction Book contains 63 pages of text, and begins with a general description of the brake which is followed by descriptions of the air-pump, the triple-valve, the engineer's brake, and equalizing discharge-valve, the pump governor, general arrangement of the brake. All of these chapters refer to the brake for passenger trains. This is succeeded by a description of those parts of the brake for freight cars which differ from those for passenger cars. The concluding portion relates to the arrangement of levers, the power of the brake, and the distance in which trains may be stopped.

A book of this kind has been very much needed, and the want has been admirably filled by the publication before us. It is bound in morocco, and with the exception of the printing of some of the excellent engravings, the work is very well done. The life of the large sheets of engravings, in the hands of some of the people for whom the book is intended, will, it is to be feared, be a short one.

In addition to the Instruction Book the Westinghouse Company have also issued a pamphlet of eight pages, the same size as those of the book, with the title "Don't." It tells persons who use the brake what not to do, and is excellent in its way.

BUFF & BERGER'S HAND-BOOK AND ILLUSTRATED CATALOGUE OF THEIR ENGINEERS' AND SURVEYORS' INSTRUMENTS. No. 9 Province Court, Boston.

This is a book of 150 pages with about half that number of engravings of the instruments made by that firm, with descriptions of them and directions for their care and use, and is a treatise which every engineer who has occasion to use such instruments should read.

In the August number of the JOURNAL we published a "note" read before the Institute of Mining Engineers, by William P. Blake, on the Use of Aluminum in the Construction of Instruments of Precision. As this subject is attracting a good deal of attention, and as there are some popular misapprehensions regarding the subject, the following extract from Messrs. Buff & Berger's catalogue will be of interest, especially as it is the expression of the views of practical instrument makers. They say:

> We believe, in the present state of its development it is not a suitable material for precision instruments. . . . The disadvantages are that pure aluminum, although very rigid, is nevertheless a very soft metal like tin, but when alloyed with 20 per cent. or 30 per cent. of copper, it becomes so brittle as to break like glass."

The volume is what its name implies, a "hand-book," and an excellent treatise on the care and use of field instruments.

CATALOGUE AND PRICE LIST OF ENGINEERING SPECIALTIES MANUFACTURED BY THE CURTIS REGULATOR COMPANY; Boston.

This is a small pamphlet issued by the above company and describes the various articles which they make, consisting chiefly of pressure regulators for both steam and water, expansion traps, steam traps, damper regulators, combined separators, and traps. The construction of these is all described and they are illustrated with very neat engravings. The pamphlet is so small that it can readily be carried in the pocket, and contains a great deal of information which is interesting and useful to those who use the appliances described. The only criticism that suggests itself is that the type is rather small for those of us who have passed our semi-centennial, and who are condemned to the constant companionship of spectacles.

BOOKS RECEIVED.

REPORTS OF THE INTERNATIONAL AMERICAN CONFERENCE: 1. ON AN INTERCONTINENTAL RAILROAD LINE. 2. ON POSTAL AND CABLE COMMUNICATIONS WITH CENTRAL AND SOUTH

AMERICA. 3. ON AN INTERNATIONAL MONETARY UNION. 4. CONCERNING A PLAN OF ARBITRATION FOR THE SETTLEMENT OF DISPUTES BETWEEN THE AMERICAN REPUBLICS. 5. MESSAGE OF THE PRESIDENT OF THE UNITED STATES AND LETTER OF THE SECRETARY OF STATE TRANSMITTING REPORTS AND RECOMMENDATIONS. Washington ; Government Printing Office.

TRIPLE-EXPANSION ENGINES AND ENGINE TRIALS : BY PROFESSOR OSBORNE REYNOLDS, LL.D. EDITED BY F. E. IDELL, M.E. New York ; the D. Van Nostrand Company (Science Series, No. 99 ; price, 50 cents).

ANNUAL REPORT OF THE COMMISSIONER OF DAMS AND RESERVOIRS OF THE STATE OF RHODE ISLAND. L. M. E. STONE, COMMISSIONER. Providence, R. I.; State Printers.

REPORTS OF THE CONSULS OF THE UNITED STATES : BUREAU OF STATISTICS, DEPARTMENT OF STATE. NO. 118, JULY, 1890. Washington ; Government Printing Office.

TRANSACTIONS OF THE WAGNER FREE INSTITUTE OF SCIENCE : VOLUME III. CONTRIBUTIONS TO THE TERTIARY FAUNA OF FLORIDA : BY WILLIAM HEALY DALL, A.M., PALEONTOLOGIST TO THE U. S. GEOLOGICAL SURVEY. Philadelphia ; published by the Wagner Free Institute of Science.

ANNUAL REPORT OF THE OHIO & MISSISSIPPI RAILWAY COMPANY FOR THE YEAR ENDING JUNE 30, 1890. Cincinnati, O.; issued by the Company.

THE IRON AND STEEL SCHEDULE OF THE NEW TARIFF LAW : THE NEW RATES COMPARED WITH THE OLD. Cleveland, O.; issued by the *Iron Trade Review*. This pamphlet will be exceedingly convenient to all interested in the iron trade. It is clearly printed, in type of a good size.

TEIKOKU DAIGAKU (IMPERIAL UNIVERSITY OF JAPAN) : CALENDAR FOR THE XXII-XXIIID YEAR OF MEIJI (1889-90). Tokyo, Japan ; published by the University.

SLOW-BURNING CONSTRUCTION : WITH TABLES OF SAFE LOADS UPON BEAMS : BY C. J. H. WOODBURY. Boston ; issued by the Manufacturers' Mutual Fire Insurance Company.

ANNALI DELLA SOCIETA DEGLI INGEGNERI E DEGLI ARCHITETTI ITALIANI ; 1890, FASCICOLO IV : ING. C. C. BARAVELLI, SEGRETARIO. Rome, Italy ; published by the Society.

AIR ENGINES : ILLUSTRATED DESCRIPTION AND ACCOUNT OF TESTS. Boston ; issued by the Woodbury, Merrill, Patten & Woodbury Air Engine Company.

COMPOUND LOCOMOTIVE ENGINE AND SUBSTITUTE. Paterson, N. J.; issued by H. A. Luttgens. This is a description of Mr. Luttgen's patent locomotive smoke-stack damper.

THE IRON, STEEL AND ALLIED INTERESTS OF JOHNSTOWN : FOR THE INFORMATION OF THE VISITING MEMBERS OF THE FOREIGN AND AMERICAN TECHNICAL SOCIETIES. Johnstown, Pa.; published by the Local Reception Committee.

THE WESTINGHOUSE AUTOMATIC BRAKE : ILLUSTRATED CATALOGUE, 1890. Pittsburgh, Pa. ; the Westinghouse Air Brake Company.

ABOUT BOOKS AND PERIODICALS.

AMONG the articles in BELFORD'S MAGAZINE for October will be found one on Irrigation and Legislation, by R. J. Hinton, which has a direct practical application just at present. There are other articles of much interest, including a sketch of the late Matthew F. Maury, who did so much for Hydrographic science.

The resources of the new State of Washington are summed up in the first article in the OVERLAND MONTHLY for September. This is a historical number, in which the leading articles are on Fremont, by J. C. Davis ; Who was the Pathfinder ? by H. L. Wells, and the Beginnings of California, by F. I. Vassault. The Pious Fund of California is a note of a little known episode in the early history of the State.

Among the articles of interest in the POPULAR SCIENCE MONTHLY for October are Irrigation in China, by General Tcheng Ki Tong ; Cotton Spinning North and South, by H. V. Meigs ; Ancient Dwellings of the Rio Verde Valley, by Dr. E. A. Mearns ; Barrier Beaches of the Atlantic Coast, by F. J. H. Merrill. There are a number of others equally interesting, though having less special bearing on engineering topics.

The National Guard of Minnesota is the subject of an article in OUTING for October, which shows how prominent a place the Guard has taken in the West. This series of articles is the work of competent military authority, and both the praise and the criticisms contained should do good. The articles are timely for another reason also, and it is to be hoped that they will arouse that public interest in the National Guard which should be felt in every State.

The articles describing the cruise of the new Squadron of Evolution are continued in SCRIBNER'S MAGAZINE for October, with Mr. Zogbaum's excellent illustrations. Mr. John W. Root tells of the development of the City House in the West, and H. L. Webb has an excellent description of the laying of an ocean cable. Professor Shaler's second article on Nature and Man in America deserves a careful reading.

Mr. Theodore Child's articles on the South American republics are continued in HARPER'S MAGAZINE for October by one on Agricultural Chili, which does not give an altogether attractive picture of the State which we are accustomed to consider the most progressive of our southern neighbors. The First Oil Well is the subject of a paper by Professor Newberry, who dates back the discovery of petroleum some 3,000 years beyond that commonly given.

The Death Penalty ; the Censorship of Morals ; an Endowed Press ; the Race Problem ; Trusts ; Schools and Churches are among the many subjects which the ARENA for October includes in its very comprehensive table of contents. All these topics are handled freely and with no lack of ideas ; the object of this magazine is to bring out discussions on topics of present interest and free expressions of opinion, and so far it has been very successful.

Monographs on important engineering works are among the most valuable contributions to technical literature. Dealing closely with details as they should and generally do, they will often give the student or the engineer an insight into matters which he will seek in vain in larger works, where attention is necessarily given more to general principles. One such work —Mr. Boller's Report on the Thames River Bridge—is referred to in another column. Another, which is now in press and will shortly be issued, is an account of the WASHINGTON BRIDGE over the Harlem River in New York, written by Mr. William R. Hutton, the Chief Engineer under whose charge the structure was built. The proof sheets show that description of this bridge is a very complete one, and it is admirably illustrated, not only by numerous views from photographs, but also by very complete drawings giving all the details of the work. It will be a valuable addition to the library of every bridge engineer. It is published by Mr. Leo Von Rosenberg, of New York.

Our very energetic contemporary, ARCHITECTURE AND BUILDING, on October 4 issued a special number devoted to School-House Architecture—a very timely one in view of the attention just now attracted by the subject. The issue contains 21 new designs by architects who have made school-houses a special study ; it is profusely illustrated, and is in every way a number of especial value.

COLOR-BLINDNESS.

To the Editor of the Railroad and Engineering Journal:

THE popular idea of "color-blindness," as it is called, falls curiously short of the reality; it is common to hear it spoken of as a disease, a state of being to be inherited, and a case for doctors to study, but probably incurable. There is, however, good reason to doubt if this is ever the true description of the matter; on the contrary, there are plausible reasons for considering and treating that which is called color-blindness as a faculty, an accomplishment to be acquired.

And while color is not to be entirely eliminated from the *materia* of signals, the idea of testing a man's eyes in relation to his capacity for distinguishing such signals is richly absurd, and ridiculously foolish.

It is probably true that, while but few ever recognize or practise this faculty with any definite knowledge or thought, the accomplishment is in a greater or less degree almost universal, and a person who cultivates the art sees any particular color or not at will. The fact that color-blindness is often temporary and increases or decreases at different times in the same individual seems to be passed over without notice; and the other fact that the human eye, in respect to the faculty of distinguishing color or light, and conversely darkness, is affected by barometric, hygrometric and thermometric influences, or that motion pure and simple may affect the nerves of the eye in the same manner as light or color, is apparently forgotten; yet probably a sharp blow on the head, especially when near the eye, would, by the simple jarring of the optical nerves, produce the same effect as a brilliant light upon any person—any boy can tell how to make one "see stars." A similar effect may be produced by simple pressure of the fingers upon the closed eyes, and the various stomachic conditions known to produce headaches, or heaviness and dullness of the faculties, find the optical nerves among the easiest to disturb.

A person on a warm muggy evening had occasion to enter a dark room, and suddenly seemed to be enveloped in a diffused light as bright as that of gas; the effect lasted some time, long enough for the observer to note and reason that, as none of the objects known to be at hand were visible, the apparent light, instead of enveloping him, was literally all in his eye, and also to note that, beside the close, heavy atmosphere and a tendency to headache, there was no feeling either painful or otherwise to be connected with the phenomenon; and he experienced a slight regret that, being alone, there was no one to tell him whether his eyes shone like a cat's or not; later observations of such cases made this appear very improbable.

When it is considered that all of color as relating to any one individual is simply different effects produced by different causes upon the nerves of the eyes, it becomes apparent that the same causes may produce different effects. In this respect the nerves of the eye are not so very dissimilar from those of the ear, which it is well known can discriminate such slight variations of sound that when a number of voices sing or instruments play as nearly as possible the same sound, the trained ear will distinguish a single one, and even one at will, to, in a great degree, the exclusion of all others. Thus the eye may be trained and under control so as to select any shade of color and see that both more quickly, more distinctly and more strongly than any other; and the same is true with regard to forms.

A boy, looking up from his book in a room where the wall-paper was of a green on gray, with Prussian blue spots about ¾ in. in diameter and 6 in. apart, saw nothing but the blue spots, the other figures appearing all blank; a repetition of the case arousing his curiosity, he found that by a slight effort he could at any time see the blue spots, banishing everything else, or banish the blue spots and see all of the other colors clearly and plainly. The effort in this case he describes as simply trying, as in case of seeing double, by focusing the eyes beyond the object looked at.

Cultivation of this art will enable the observer to increase or decrease the effect of any color, as in a carpet or wall-paper pattern, and also to substitute their negative neutrals, or in case of mixed shades, to separate, giving extra effect to one or more of the components. Thus orange may be made to appear more red or more yellow not merely by juxtaposition, but by the same effect produced by muscular efforts in the eye itself.

Juxtaposition is one of the most common causes of mistakes in color; some combinations are absolutely painful to the eye, causing it to ache, as when trying to use spectacles that do not fit. Yet the designer of frescoes may be so far color-blind as to take a saucer of green paint for vermilion, and yet the public approve of his labors.

That color may or may not be always seen by the same eyes is a matter not only subject to control by the will, but it is also liable to be affected by habit or association. A person has seen the bright colors of a piece of calico change, while he looked, to their negatives, and for years after found it a matter of effort to ever see those colors in that piece of cloth, although the same colors or combinations were perfectly clear elsewhere; again, the negatives having been seen in the place of the colors in one part of a carpet, the colors may be clear and perfect all over the rest of the floor, yet upon turning the eyes to the same point again, the negatives persistently assert themselves.

In view of these facts, it appears that "color-blindness" is more a matter for the schoolmaster than for the doctor to deal with, and more can be accomplished by instruction and practice than by medicine and surgery.

ALOHA VIVARTTAS.

PISTON ROD BREAKAGES.

(From the *Practical Engineer.*)

TO the practical engineer, one of the most interesting portions of Mr. Longridge's report deals with the particulars of breakdowns of engines insured by his company. These breakdowns may be classified as under:

37	per cent.	due to	causes purely accidental or unascertained.
18	"	"	negligence of owners or attendants.
14	"	"	old defects and wear and tear.
31	"	"	weakness from faulty design or bad workmanship.

The particular part of the engine to which the damage in each case seemed to have been due, or where the damage was due to something external to the engine, the part which seemed to have broken first, is given in the following list:

	Numbers. During 1889.	Numbers. During previous 9 years.	Numbers. Totals.
Spur gearing	20	214	234
Valves and valve gear	25	211	236
Air pump motions	13	140	153
Air pump buckets and valves	8	92	100
Columns, entablatures, bed plates and pedestals	11	67	78
Bolts, screws, jibs, cotters and straps	15	67	82
Main shafts	7	58	65
Parallel motions, links and guides	8	57	65
Pistons	3	35	38
Cylinders, valve chests and covers	3	29	32
Flywheels	2	26	28
Piston rod crossheads	6	25	31
Piston rods	4	23	27
Cranks	1	21	22
Governor gear	1	20	21
Air pumps and condensers	4	18	22
Crank pins	1	12	13
Gudgeons in beams	2	11	13
Beams and side levers	0	9	9
Connecting rods	1	8	9
Total wrecks, cause unknown	0	5	5
Second motion shafts	0	1	1
Main driving ropes	1	0	1
	136	1149	1285

This list points out very clearly the weak parts of mill engines generally, if the engines insured by this company

be, as they probably are, a fairly representative selection, and for this reason it is commended to the attention of millowners and engineers.

To describe all the breakdowns for the year in detail would be impossible ; to leave them altogether without comment would be inconsistent with the objects of the company in publishing these reports. A selection, therefore, must be made. Last year spur gearing was considered. This year it is proposed to say something about piston rods and crossheads.

The breakdowns Nos. 26, 38, 126, were caused by piston rods breaking at the cotter-holes within the crossheads, and No. 135 by the breakage of an air-pump rod at the same place. The ends of the rods are shown in figs. 1 to 4 on this page, the position of the fracture being indicated in each case.

Fig. 1 was the wrought-iron rod of a horizontal Corliss condensing engine. The cylinder was 34 in. diameter,

FIG. 1.

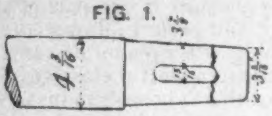


FIG. 2.

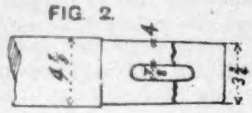


FIG. 3.

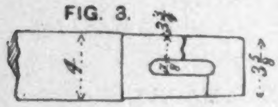


FIG. 4.

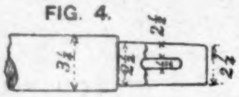


FIG. 5.

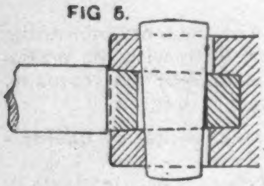


FIG. 6

FIG. 7.

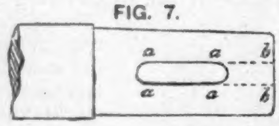


FIG. 8.

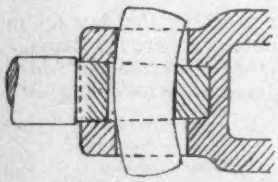


FIG. 9

FIG. 10.

the stroke 5 ft., the speed 43 revolutions per minute, the maximum effective pressure from 60 lbs. to 65 lbs. per square inch, and the point of cut-off about $\frac{1}{8}$ of the stroke. The maximum load upon the rod was, therefore, from 55,000 lbs. to 60,000 lbs. The sectional area of the fracture was 5 square inches, so that the stress per square inch, if uniformly distributed, would not have exceeded from 11,000 lbs. to 12,000 lbs. The rod was put in new in March, 1883 and a new cotter was fitted in January, 1889. In March, 1889, the rod gave way, having been subjected to about 87,000,000 applications of the stress since it was put in, and to about 3,000,000 since the new cotter was fitted. It is said that the rod was sound when the new cotter was put in.

Fig. 2 was also the wrought-iron rod of a horizontal Corliss engine ; diameter of cylinder, 36.3 in., stroke of piston, 5 ft., revolutions per minute, 40, maximum effective pressure, 50 lbs. per square inch, point of cut-off about one-tenth of the stroke. The load upon the piston was therefore about 51,000 lbs., and the stress upon the rod, if uniformly distributed over the fractured section, a little over 8,000 lbs. per square inch, the sectional area of the fracture being about 6.6 square inches. The rod and cotter were put in in 1872, and had therefore been subjected to about 230,000,000 repetitions of stress alternately tensile and compressive.

Fig. 3 was a steel rod of the same size and shape as fig. 2. The engine in this case was a horizontal Corliss engine ; cylinder, 32½ in. diameter, stroke, 5 ft., revolutions, 39 per minute, maximum effective pressure from 60 lbs. to 65 lbs. per square inch, point of cut-off from one-eighth to one-tenth of the stroke. The sectional area of the fracture was about 6.6 square inches, and the stress upon this area due to the steam pressure from 8,000 lbs. to 9,000 lbs. per square inch. The rod was put in in 1882, and a new cotter in 1886 ; it had, therefore, sustained 92,000,000 applications of the load since it was new, and 40,000,000 since the new cotter was fitted, the stresses being alternately tensile and compressive. The new rod which replaced it has since given way at the same place, after making only 6,500,000 strokes. This rod was of the same dimensions as the old one, but of iron.

The rod represented in fig. 4 was, as has been stated, an iron air-pump rod. The pump was vertical, 24 in. diameter by 3 ft. stroke, and the bucket made 39 strokes per minute. Taking the pressure on the bucket at the moment when the head valve opened at 20 lbs. per square inch, the stress per square inch of fractured area would be 3,200 lbs. The rod had worked since 18—, but had had a new cotter about the year 1882. It had, therefore, borne a tensile stress of about 3,200 lbs. per square inch, 92,000,000 times altogether, and 46,000,000 times since the new cotter was fitted.

For the sake of clearness the intensities and number of applications of the stresses borne by these rods are tabulated below :

Description of Rod.		Intensity of Stress.		No. of Applications of Stresses.	
		Tensile.	Compression.	Tensile.	Compression.
		lbs. per square in.	lbs. per square in.	Millions.	Millions.
Fig. 1.	Iron piston rod ..	11500	11500	43½ altogether.	43½ altogether.
"	" ..	"	"	1½ after fitting new cotter.	1½ after fitting new cotter.
Fig. 2.	Iron piston rod ..	8000	8000	115	115
Fig. 3.	Steel piston rod..	8500	8500	46 altogether.	46 altogether.
"	" ..	"	"	20 after fitting new cotter.	20 after fitting new cotter.
"	Iron rod replacing steel rod	"	"	3¼	3¼
Fig. 4.	Iron air-pump rod	3200	....	92 altogether.	....
"	" ..	"	....	46 after fitting new cotter.	...

Now, why did these rods break ? Had the materials of which they were made been broken in a testing machine, the iron would probably have been found to possess a tensile strength of about 50,000 lbs., and the steel of about 70,000 lbs., per square inch. Even under the conditions under which they were placed—subjection to constant repetitions of stress—our present knowledge would lead us to suppose that the iron piston rods would have withstood stresses of about 17,000 lbs. per square inch, and the steel of about 23,000 lbs., for a very great if not indefinite number of applications, while the air-pump rod, in which the stress was practically only in one direction, would have borne about 30,000 lbs. But these stresses are greatly in excess of the stresses upon the broken rods if uniformly distributed. It would, therefore, seem either that the average stresses upon the rods were greater than has been stated, or that the stresses were not uniformly distributed, but were of greater intensity at some points of the cross-sections than at others. As regards the piston rods the latter was probably the case ; as regards the air-pump rod, it is possible that the stress may have considerably exceeded that obtained by dividing the load by the area of the rod, because the load on an air-pump rod is suddenly ap-

plied and is frequently of the nature of an impulse. But there is little doubt that in this case also, fracture was, to a great extent, the result of concentration of stress at one particular point. In each case the fracture commenced at the edge of the cotter-hole, and extended gradually across the rod until the latter was so much weakened as to break off short. This seems to indicate the cause. Consider figs. 5 and 6, and imagine what would happen if the cotter were driven up. Clearly, the whole stress would be borne by the small, sharp-edged bit of rod shown shaded in fig. 6, and would attain a great intensity. Imagine, further, that the conical part of the rod was not an exact fit in the crosshead, but was tighter on the left side than on the right. What would follow on driving up the cotter? Clearly this: The stress, instead of being distributed between the two shaded areas, would be concentrated upon the left-hand one, especially with square-edged cotters. Even supposing the cotter to be a perfect fit in both rod and crosshead there will still be a greater stress along the edges of the cotter-hole than elsewhere; for, in the first place, if the draw of the cotter be resisted by a shoulder on the rod, or by the larger end of the conical part, the whole pressure of the cotter (no slight one if the cotter have little taper and be driven hard), as well as the stress from the steam pressure, will come first upon the layers of material (marked *a a* in fig. 7) which form the sides of the cotter-hole, and these layers will, in consequence, be stretched more than those outside them. If the rod end butt against the crosshead, the part between the layers *a b* will be compressed more than those outside by driving up the cotter, but *a a* will still bear the burden of the load upon the engine; and thus, in either case, the strain in these layers will be greater than in the other parts of the rod.

In the second place, the strain will be greater at the outside edges of these layers than in the middle, because the tendency of the cotter when driven up is to bend to the shape shown in fig. 8, and consequently to bear hardest at the outside of the rod.

Lastly, there is the possibility of the slides not running in exactly the same horizontal plane as the rod, or of the slide bars wearing, and so bringing a bending movement upon the rod, which, if the rod were not a tight fit in the crosshead, and if the cotter were driven vertically, would throw a heavy stress upon the top and bottom fibers of the layers *a a*, fig. 5.

Seeing, then, how many possibilities there are of distributing the average load upon a rod unequally, and of intensifying it enormously at the outside edges of the cotter-hole, the conclusion that these rods broke from excessive stress localized at the edges of the cotter-holes seems not unreasonable. The remedy appears to be to round off the edges of the cotter-holes, as shown in figs. 9 and 10, and thus increase the area by which the maximum intensity of stress must be resisted, to butt the ends of the rods against the crossheads, and to drive the cotter in a plane at right angles to the plane in which the connecting-rod moves. As to the form of the end of the rod itself, it is perhaps a question whether it should be conical or cylindrical, but there can be no doubt as to the propriety of dispensing with the shoulder shown in figs. 1 and 4. Perhaps the better plan would be to make the rod end cylindrical of the same diameter as the working part, and to bush the crosshead when the rod requires turning down.

At all events, there can be no doubt that the utmost care should be taken in fitting the cotters, and that cotters showing signs of working loose should never be driven up without careful examination of the ends of the rods. Moreover, the writer's opinion is that the sectional area at the cotter-hole should be sufficient to reduce the strain to about two tons per square inch, unless there be good reason for the contrary.

Fig. 4.

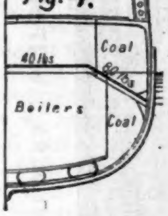
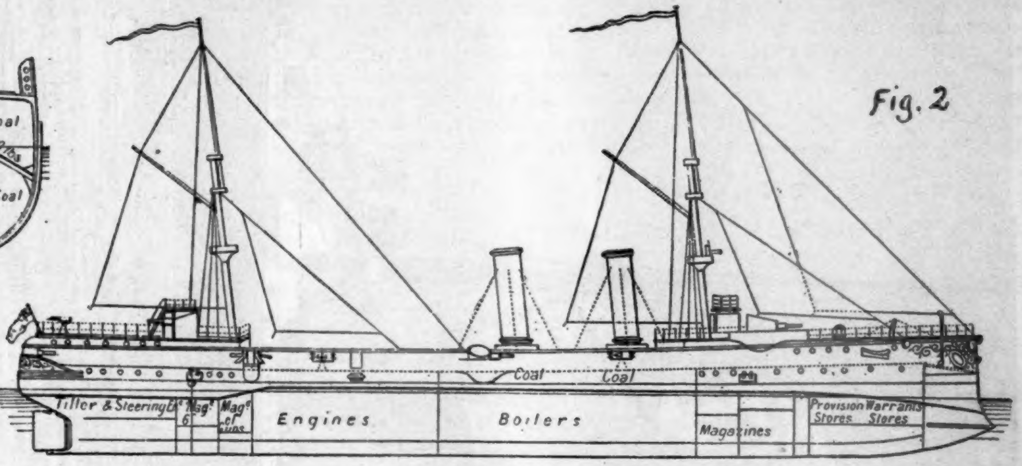
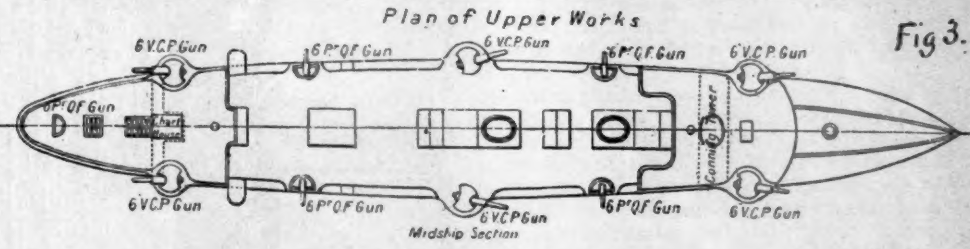


Fig. 2



Plan of Upper Works

Fig 3.



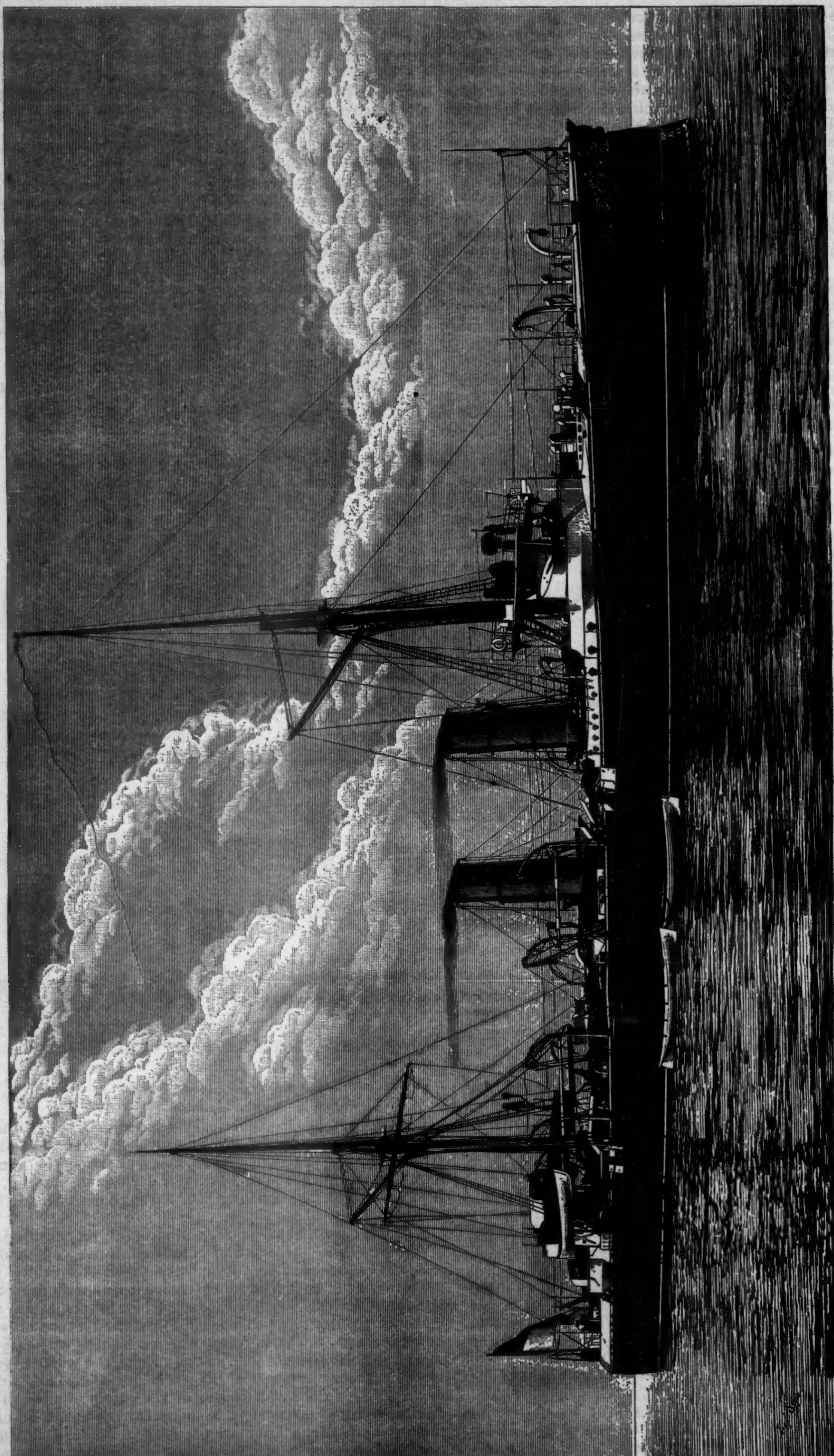
Midship Section

AN ENGLISH FAST CRUISER.

(From the London *Engineer*.)

THE accompanying illustrations show the English cruiser *Medusa*, the large engraving being a general view, taken from a photograph; fig. 2, a side view showing the general arrangement of the ship; fig. 3, a deck plan, and fig. 4, a half cross-section, showing the arrangement of the coal bunkers, etc.

The *Medusa* belongs to a distinct type, entitled the "*Medea* class," which first consisted of five vessels only, but has subsequently, under the new Admiralty programme, developed into an extensive *genus* with increased size and various modifications. It embraces many new features in design and construction, and represents an auxiliary arm to the fighting line, consisting of heavy armored battleships alone; just as of old, the swift frigates were necessary adjuncts of the great line of two and three-deckers. As the five cruisers of the group alluded to are similar in most respects, it appears convenient to describe them generically. They are the *Medea*, *Medusa*, *Melpomene*, *Magicienne* and *Marathon*. The first two were



SECOND-CLASS STEEL PROTECTED CRUISER "MEDUSA," BRITISH NAVY.

built at Chatham, the *Melpomene* at Portsmouth, and the two last-named in the yard of the Fairfield Shipbuilding & Engineering Company at Govan, Glasgow. The vessels are alike in their dimensions and in their internal arrangements, but the constructive materials and engines are different. The *Medea* and *Medusa* are built entirely of steel, and their displacement tonnage is 2,800 tons. Their engines are placed vertically, with inverted cylinders. They were designed to realize a speed of 20 knots; and for the purpose of showing at what an enormous expenditure of energy these high speeds are attained, it may be mentioned that the *Medea*, with a displacement of 2,800 tons, is fitted with engines of substantially the same indicated H.P. as the 16½-knot armor-clad *Collingwood*, with a displacement of 9,500 tons, or between three and four times the weight. The engines are of the twin-screw triple-expansion type, with cylinders of 33½ in., 47 in. and 74 in. respectively, and a stroke of 39 in, and are under the protection of the sloping armor deck. In the case of the *Marathon*, *Magicienne* and *Melpomene*, the steel hulls are sheathed with wood and copper to enable them to remain afloat for long periods in any climate, without having their bottoms fouled, and their speed consequently reduced. This sheathing increases the displacement to 2,950 tons, and the speed was, consequently, expected to be reduced by about ¼ knot, or to be 19¾ per hour. Even in view of this slight loss of speed and the additional first cost which such an arrangement involves, the change of plan is acceptable, as it gives these cruisers an additional advantage over ordinary vessels, enabling them to remain at coaling or other stations for a long period, and to be afterward available for speedy employment without the necessity of entering a dock in which to have the bottom cleaned. The wood sheathing consists of two thicknesses of teak, making together a thickness of 6 in. The inside layer is attached to the steel hull by iron bolts, and the outside one by bolts of gun-metal. The bottom is further covered with sheets of copper nailed to the teak.

As showing the difference caused by fouling of the ship's bottom, it may be stated that with a rough bottom 5,800 H. P. gave a speed of only 16.9 knots, while when nearly clean the same power gave 17.6 knots an hour. At a speed of 13 knots, 2,000 H. P. were required when the ship was foul, while 1,600 H. P. were sufficient with a clean bottom.

The ram, stem, stern and rudder posts, and the brackets for supporting the twin screws of the sheathed *Medeas*, are all cast in solid bronze, these castings together weighing for each ship about 45 tons.

For protection the vessels depend principally upon a 2-in. steel deck, worked into the framing and extending from stem to stern. This deck is turtle-backed, having a declivity at bow and stern, and along the sides of the vessel. The top level of the deck, in the center of the ship, is about a foot above the water-line, and the declination all round makes the connection of the deck with the sides of the ship at a point about 5 ft. from the water-line. Under this deck are placed the propelling engines and the machinery for working the ship—all the vital parts of the mechanism—as well as the magazines. The coal bunkers are arranged above and below the deck, in that part of the vessel where the engines, boilers, etc., are situated, so that additional protection may thus be secured. While on this subject we may mention that, at the experiments with the hull of the *Resistance* last year, it was found that the filled coal bunkers absorbed more of the energy of high explosive shells which succeeded in effecting penetration, than any other form of protection adopted. The *Medeas* have a double bottom on the cellular principle for carrying water ballast. The immense advantage of these double bottoms has been conclusively proved quite recently. When a heavy shell fell to the bottom of the *Howe*, it pierced the inner skin. Had there not been a second skin the vessel's safety might have been endangered. Similarly, the *Temeraire* was only saved by her double bottom when in collision with the *Orion*. The interior of the hulls of these vessels is divided by bulkheads into ten main water-tight compartments, two of which are occupied by engines and two others by boilers. These four have no doorways between the spaces, but in some of the other bulkheads there have been fitted doors workable either at the door or from the top deck. In addition, these main compartments are subdivided, especially above the protective deck, there being in all close on 270 water-tight spaces.

The armament consists of six 6-in.—5-ton—breech-loading steel rifled guns, on central pivot Vavasseur mountings, two placed forward, two aft and one on either broadside amidships; ten 6-pounder and one 3-pounder quick-firing guns, three light guns and several machine guns. Six torpedo tubes are fitted on board, all under cover, one forward, one aft and two on each broadside.

Accommodation is provided for about 300 men all told. There are two funnels and two masts. The cost of the *Medusa* and *Medea* was about $430,500 each for ships, and $259,600 each for machinery. The principal dimensions of all the five vessels of this type are as follows: Length, 265 ft.; beam, 41 ft.; draft for sheathed portion, 17.6 ft.; for unsheathed portion, 16.6 ft.; tonnage of first, 2,950 tons; of second, 2,800 tons; coal accommodation for 400 tons, sufficient for 8,000 knots at 10 knot speed.

Some slight modifications have recently been made in the bridges and superstructure of these ships, which were found to be inconvenient. One most fortunate circumstance in regard to them all is that the bow wave, in forming its curves along the sides of the vessel, just clears the sponson projections, which, consequently, do not impede the progress of the ship, as in the *Severn*, *Mersey* and *Thames*.

PREMIUMS TO RAILROAD EMPLOYÉS.

(Paper submitted to the International Railroad Congress at Paris by M. Bela Ambrosovics, of the Hungarian State Railroads.)

ACCORDING to moral and social law, the relations between industrial enterprise and their agents should extend beyond those mutual duties which are stipulated in the written contracts and regulations of service. The latter do not pass the limits prescribed by the idea of fidelity—giving this word a somewhat larger meaning than that of the penal code—and mutual service ends when the belief arises on one side or the other that what is demanded is not a service, but a sacrifice.

Without doubt there are agents whose conscience is scrupulous, either by nature or by education, and whose activity is not satisfied by the legal minimum of work. On the other hand, there are also companies which are generous toward their employés; but in any case sentiment and individual ideas are not sufficently solid bases upon which to act in establishing that principle of mutual concession which is always just, and the application of which is so much to be desired.

It is this desire of appreciating the value of the surplus of care and work resulting from zeal—whether produced by moral or material interest—which has without doubt induced the International Commission to put down in the programme of the Milan Congress the question of the best method of interesting employés of railroads in the financial prosperity of their lines.

This is a very important question for the railroad managements, as indeed are all those which relate to financial success. If they are well managed, in such a way as to satisfy external interests, it is something, but it is also necessary to manage them so as to secure a profit for the enterprise. It is a problem, the solution of which demands in unfavorable circumstances most minute care, deep study, and especially practical sense developed upon a solid theoretical basis and by long experience.

At the Milan Congress the question was not discussed in its full extent. Only the question of premiums for economy was considered, while that of increasing receipts by the constant watchfulness of agents was not directly discussed, but only incidentally spoken of on my own proposition. The debate only brought out general ideas, and even in relation to premiums for economy the principles were not sufficiently developed. It is therefore necessary to bring up the question again, and for that reason the In-

ternational Commission decided to bring it forward once more at the third session of the Congress.

The Milan Congress reached three conclusions :

1. It recommended in principle the utility of the system which will give to agents who render special productive service some participation in the profits of the enterprise in addition to their regular salary—a personal participation applying the maxim "to each man according to his work."

2. It favored the extension to all branches of railroad service of the system of premiums for economy wherever the regularity and the safety of operation would not be endangered.

3. It recommended a system of premiums on increased receipts for agents who can act to secure an increase of traffic.

It may be said that by these conclusions the Congress favored in principle the solutions presented to attain the desired end, since no other means can be reasonably imagined to interest employés immediately and directly in the profits of an enterprise than payments to those to whom the increase of profit is due. There are only two ways of carrying out this plan : the first by giving a share in savings to those who secure such savings and in increased receipts to those who secure the increase, or, second, by giving a share to the employés of the two classes named of the net profit of the enterprise.

The differences between a system of premiums and a system of participation consists in this : That in the first case the amount of the remuneration is established in advance, while in the second everything is left to the views and generosity of the management. It remains to examine which of those two systems is preferable, and to see how they may be applied.

PREMIUMS FOR ECONOMY.

Concerning premiums for economy, the Milan Congress enunciated the very just principle that the system of premiums ought not to be applied to those branches of the service on which depend the security and the regularity of management. This, I think, ought not to be taken in a too absolute sense, but ought to be extended in this sense, that the system of premiums should be restricted to the service where the work of the employés can be and really is strictly controlled with regard to safety and regularity. Premiums for economy appear then to be desirable under several heads.

1. For all economies in the consumption of materials used in service which do not belong strictly to the management of the road. These are materials for heating, lighting and cleaning offices and places not open to public use ; materials necessary for office work. For these classes of materials, it seems most advantageous to allow a fixed sum to the employés interested, and to divide any saving among them. In this case, in determining the quantity required upon which the fixed sum is to be based, all the circumstances by which these quantities may be influenced should be taken into consideration. For materials necessary to produce motive power, both on the road and in the workshops, and for the care and maintenance of machines—such as fuel, oil, etc.—a fixed allowance for the unit of work seems most to be recommended. It may be noted that, as to economy in locomotive fuel, it is hardly safe to allow premiums on lines with heavy grades, unless a strict control is exercised over the speed of trains, since it is well known that engine-drivers and firemen, to save fuel, will often travel slowly, trusting to make up time on down grades, sometimes without regard to safety.

2. For economy in the ordinary expense of maintaining the substructure of a railroad, the road-bed, drains, ditches, etc.

3. For economy in the ordinary expense of maintaining roads, water-ways, etc., which the railroad is obliged to keep up.

4. For economy in the ordinary expense of maintaining the track.

5. For economy in the ordinary expense of maintaining the buildings.

6. For economy in expenses relating to yard work at the more important stations, and the handling of freight.

To settle the amount of all these economies, the systems vary according to the nature and circumstances of the case. In general the plan to be recommended is to establish as much as possible premiums based on a unit of price reasonably defined for each sort of work. When we consider works where the quantity of work to be furnished or the number of units depends chiefly upon the employés, it is necessary to fix a maximum which must not be passed without special permission, on penalty of losing premiums, or even of fines. It would be possible, however, with a careful control, as far as safety is concerned, to recognize rational economy and to allow premiums separately for saving any materials below the quantity established.

PREMIUMS FOR INCREASE OF RECEIPTS.

When the Milan Congress recommended the system of premiums on increased receipts for agents who could secure an increase of traffic, it was not forgotten that there are many difficulties in realizing this result.

These difficulties are evident. To create traffic it is necessary that the needs of one place should be satisfied by the surplus of another. It is always difficult to estimate the merit of the first discovery of the co-existence of these conditions and the bringing them together so that business is created. It is more difficult yet to estimate the exact co-operation in the production of this double condition. The solution of the question of premiums may be left to proofs of merit furnished by the interested agents themselves, but this proceeding, applied not in exceptional cases, but as a general rule, would probably lead to a certain demoralization among agents, who would be tempted to use doubtful expedients with shippers to the detriment of the railroad.

The strictness of the first rule laid down by the Congress concerning the participation of agents in profits, was modified in the resolution concerning premiums for increase of receipts, according to which such premiums should be established for agents who can act with effect upon the increase of receipts. This leads us to believe that the Congress, while endeavoring to establish a standard which could hardly be attained, has yet desired that its resolution should not be too strictly construed. The question, nevertheless, remains difficult.

We must consider what agents can claim to be able to increase the receipts of a railroad. In the first place it is necessary to exclude all those whose services do not relate directly to the receipts ; that is to say, the employés in those branches of service who are not in contact with the public ; then among the employés who are in the service of receipts, properly so called, those who, by their positions rather mechanical than speculative, or by their subordinate positions, have no opportunity of acting to increase business. It would also be necessary to exclude the employés of stations at commercial and industrial centers. Lastly, it would be necessary to exclude those articles in which the traffic is constant or at least only slightly variable, or, to speak more precisely, those articles the quantity of which carried does not depend at all upon the railroad agents.

Observing these principles each management could designate the agents or the groups of agents who should participate in premiums for increase of business, excluding the articles just mentioned, and could calculate those premiums on a rational basis.

One of the methods of calculation could be as follows : The average difference in the increase of receipts should be established for a short series of years, say from five to seven. To be just, no account should be taken of a very favorable or of a very unfavorable year. The marked differences should be left out and the average of the remaining years should be calculated. The receipts of the last year, *plus* the average increase, should form a basis for the receipts of the following years, due allowance being made for special circumstances. A certain percentage of the difference between the actual receipts and the receipts thus estimated should be divided among the agents. Part of this sum appropriated for premiums might be reserved to reward unusual merit, and for special objects, and it would be well to establish a maximum for the premium—based, for instance, on the fixed salary—which could not be ex-

ceeded. It is hardly necessary to say that those who have shown negligence or idleness should be excluded.

A variation of this system would be to estimate not for a single year, but to establish an average of two or three years, and to make no computation for the premiums until the end of the last year. The difficulties attaining this system are too slight for mention.

This system could be applied according to circumstances to the total receipts on certain classes of freight only; or the receipts of certain articles, the traffic in which cannot be influenced by the activity of agents, might be excluded. The premiums might be divided among all the agents or among groups of agents according to the list of articles.

Following up this point of view the systems could be changed in detail. Thus, premiums could be established not for the increase of receipts, but for the increase in quantity of certain articles shipped, or of certain articles at certain stations; or again, premiums could be paid to agents who brought to the road traffic in articles not before carried, and still other variations might be suggested.

What I wish to recommend in every case, however, is that the agents interested, and especially the heads of stations, should be caused to co-operate in preparing the estimate of receipts and that they should be required to report yearly, or perhaps monthly, on the commercial outlook and the traffic in different articles which should be expected from the activity at their stations. These reports would be valuable, because they would develop the interest of agents in business and would stimulate their zeal and commercial spirit.

It would be well also to require heads of stations to collect statistics relating to the production of articles brought to stations for shipment. These statistics would be a useful element in fixing tariffs.

It would be well in my opinion in establishing such a system to begin with a minimum percentage and afterward to regulate it as experience shows. The agents, led by their own interest, would not hesitate in aiding the management and in securing the establishment of the best method of obtaining the desired end. At the opening of a new line one of the methods mentioned could be applied in estimating the probable receipts, but naturally with much caution. It would seem best, however, to wait for the results of operation at least for the first year.

PARTICIPATION IN PROFITS.

It would be possible under this system to set aside a certain proportion of net receipts and to permit the agents to participate in this in proportion to their merit. They could be also allowed to share in the increase of profit or in the two together. As in the previous system, estimated figures as precise as possible should be established. The point which presents the most serious difficulties, more serious here than under the system described, is the valuation of merit. If, however, the principle "to each according to his merit" is applied strictly, and all agents are excluded who have shown themselves unworthy, this system could be preferred to any other on account of its simplicity.

The point of highest importance, in my opinion, is to lead the employé to identify his personal interest with that of the enterprise, and in consequence to develop in him the commercial spirit in the interest of the road. This is altogether a different thing from leaving the employé to interest himself temporarily in the results of a single branch of the service, and from developing in him a spirit of gain. It is possible to use economy which is injurious to the enterprise. A false economy is wasteful economy, and may produce accidents, the fatal consequence of which would cost more than the saving of several years. It is possible to establish tariffs or make arrangements by which an increase of receipts may be obtained for the moment, but which would be injurious to the development and future extension of traffic. A high rate upon a certain article may, for example, while increasing the receipts of a railroad, cause the shipment of the same article, or of another which could be substituted for it, but from a place situated beyond the system of the road. It may even happen that while the receipts of one system are increasing, the receipts of the whole road will be diminished.

It may be said generally that there is hardly any agent of a road who cannot render to it in one way or another a service in excess of his strict duty. In interesting all in the prosperity of the enterprise, in making them identify themselves with it, each of them will find, according to his ability and the position which he occupies, means for favoring more or less the interest of the road.

Participation of employés in profits to a reasonable degree established in advance need not prevent payment for extraordinary serv ces, and it would also be well to reserve as a provision for exceptionally bad years part of the percentage to be divided.

In applying the system of premiums in general according to the methods indicated above, it may happen without doubt that here or there an agent will gain an advantage which is not really due, but the point which can be doubted is that every individual interested will develop more zeal in his field of activity than if he did not expect payment. Concerning the exceptions, in aiming at a high standard, we cannot stop for too minute points of detail. Imperfection is common to all things in this world, especially when we are judging the actions of men. Even justice sometimes punishes the innocent. It can hardly be said that all employés without exception earn their wages, for there will always be some who look at appearances only and adroitly seem to work, but nevertheless do much less than their duty.

To seek an infallible system is to hunt for the impossible.

Concerning participation in increase of receipts or of profits, it would not be unjust to permit agents to share, provided they had done their duty under all circumstances, in the benefits produced by favorable conjunctures, or even by a fortunate chance, especially if, taking account of the chance of bad years, their salaries had been established at a minimum amount.

To apply the system of participation in the profits of an industrial enterprise is to interest employés in the results of bad as well as of good years, and to render them partners in the enterprise. It is to reconcile capital and labor and to hasten the solution of one of the most serious questions debated in our time; for if this struggle between capital and labor has existed in fact ever since society existed, it has never been as active or as important as now.

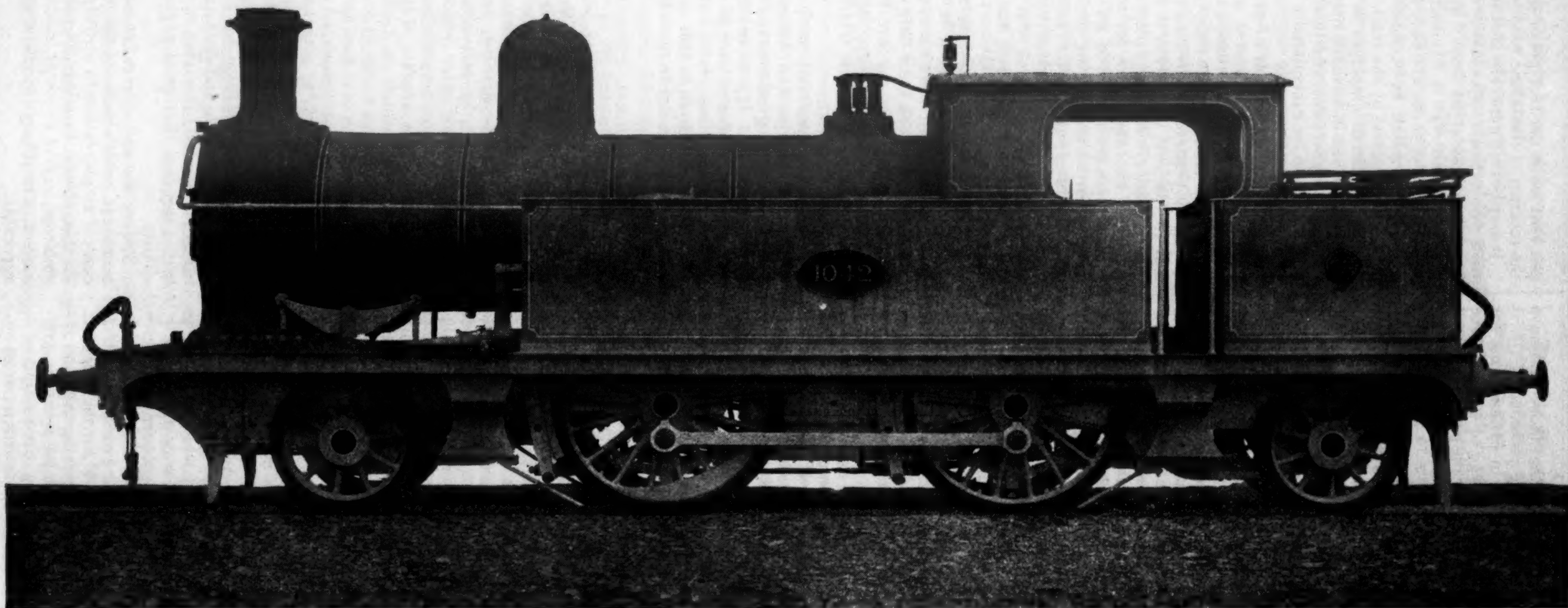
MORAL CONSIDERATIONS.

When we seek means for interesting employés in the prosperity of an enterprise by inspiring them with ideas corresponding with the modern conception of affairs, always ready to attribute a material motive to the action of men, we often forget other means leading to the same end. These not only cost nothing, but are really a clear gain to the prosperity of the enterprise. Although inspired by this same economic spirit which leads us to invent new methods, we should nevertheless cultivate and develop before all, the more because it is not done everywhere, the old principles to which we have alluded.

If money is much in life, it is not everything for a man. It is sometimes the case that a man will prefer a position, although less advantageous in a money point of view, to another more brilliant for reasons purely moral or sentimental. We see sometimes that the strict discipline indispensable in railroad service is confounded with want of consideration; energy with abuse of authority. We must not forget, whatever position we hold, that a good machine works without noise and does not wear itself out. The lubrication which oil furnishes to parts of a machine in contact is supplied the social organization by politeness and charity.

Self-esteem and esteem for superiors result from a good treatment, which is one of the most essential conditions to content employés and to identify them with the enterprise. To this should be added all proper means for cultivating ambition, *esprit de corps*, mutual consideration, etc.—in a word, everything which serves to render the service agreeable.

Thus, the methods of administration are not indifferent in this point of view. For instance, when we speak of a



"RADIAL" TANK LOCOMOTIVE FOR THE LANCASHIRE & YORKSHIRE RAILWAY, ENGLAND.

DESIGNED BY MR. JOHN A. F. ASPINALL, LOCOMOTIVE SUPERINTENDENT.

surplus of work to result from zeal in the service, it is necessary, before all, that the employé should have some leisure which would make him physically able to furnish this work, and it is necessary also that he should be in a somewhat cheerful or animated condition, which is, perhaps, still more indispensable for voluntary extra work than a material interest. Two things—of which it is difficult to say which is the cause and which is the effect—are injurious in this point of view to the interest of the railroad. They are *Bureaucracy* and *Centralism*.

Bureaucracy, where the form kills the thought, where the spirit is lost in the flow of words, not only costs time which could be much better employed in useful work, but makes the mind, by accustoming it to a barren activity, at last incapable of productive and practical work of any kind.

Excessive centralism, with a greedy desire to extend itself, on the one hand crushes the mind and limits it to superficial work, and on the other weakens it by suppressing originality and ambition in the employés scattered along the line.

Both of these, besides the expense caused by increased complication of the service, suppress the practical sense and the activity of agents, without which railroads cannot respond to what the public has a right to accept from them. Moreover, they cause employés envy, and deprive them of the possibility of sincerely interesting themselves in the prosperity of their companies. They are the more dangerous because, supported by some address, they are capable of showing results which may blind the eyes of those who do not look to the bottom of things, and only see the brilliant exterior. Everything goes well apparently; strict order reigns everywhere. The machinery works admirably; the financial result is surprising. One begins to believe in a magic power until the time when some sudden change shows, all at once, vices, defects, and mistakes which are found irreparable. This is also the principal reason why a system of premiums could be rejected when it is limited exclusively to the chiefs of branches of the service. The monopoly of material reward leads to a moral monopoly—that is to say, to bureaucracy and to centralism.

It is true that the great responsibility attending railroad service makes the observation of certain formalities indispensable, and even requires a certain degree of centralization. In consequence, a single head in the administration is necessary, but it is always desirable to restrain his action as much as possible. Always it is necessary to adopt as a maxim, "Write as little as possible," and to insist upon the principle of personal responsibility. Among those things which do not contribute to raise the feeling of honor, or to stimulate his ambition, we must always consider too strict control.

Among the means best adapted for exciting the zeal of agents and interesting them in the prosperity of the enterprise, we may consider the improved treatment of the employés, and especially those of the lower grades, which, from a point of view of expense, will compensate for the reduction in number by the use of mechanical processes; the employment of women; special rewards, for instance, for regularity in running trains; pensions for long service and provision for injuries; relief in case of sickness and similar matters, which there is not space to consider here, especially since some of these questions have been otherwise brought before the Congress.

From a point of view purely ethical—I had almost said æsthetic—one might almost be inclined to declare against any system of premiums, only admitting that all other methods, semi-material and semi-moral, except participation, have been tried. However, many reasons are in favor of the application of the principle of participation of profits, especially when they result from the decrease of expenses or the increase of receipts.

This is the delicate point of the question. The nature, the sentiments, the thought and the manners of a man cannot be regulated by a formula.

It is seen in fact sometimes that by a change of person in administration or in a branch of the service, the spirit of the direction and all the appearance of the service are modified. It is, therefore, in the interest of the service to counteract any personal influence which can eventually be unfavorable to the activity or to the zeal of the agents.

It would be very difficult to say which of the methods here treated should be preferred. That depends largely upon circumstances, and the system which might be applied with success upon one road would be a failure upon another. It would be better that each management, accepting the general principle, should join the elements indicated in the course of the discussion, and endeavor to form a complete and harmonious system, commencing in a comparatively narrow circle, determined by the special circumstances of the road, and enlarging it as opportunity offered.

This is the conclusion which I have reached after careful study. The method which, as I have said, may be best determined by local circumstances and by local conditions, is of less importance as long as no reasonable means are neglected for promoting the main object.

To make the employés zealous, they must have a direct interest in the prosperity of the railroad for which they work.

TANK LOCOMOTIVE FOR THE LANCASHIRE & YORKSHIRE RAILWAY.

THE accompanying illustration shows a tank locomotive for passenger service on the Lancashire & Yorkshire Railway, built at the shops of that company in Harwich, England, from the designs of Mr. John A. F. Aspinall, Locomotive Superintendent.

The general design is that of an engine with four coupled wheels, one pair under the boiler and one behind the fire-box, and two pairs of bearing wheels, one under the front end of the engine, the other under the coal-box. The axles of these bearing wheels are provided with radial boxes, permitting the wheels to accommodate themselves to curves, and serving the same purpose as a truck.

Water is carried in the side tanks, as shown in the engraving, and coal in the box behind the cab, which is supported by an extension of the frames.

The boiler is 50 in. diameter of barrel and 10 ft. 7⅝ in. long; it has 220 tubes, 1¾ in. outside diameter. The fire-box is 6 ft. long, 4 ft. 1 in. wide and 5 ft. 10 in. in depth. The grate area is 18.75 square feet, and the heating surface is: Fire-box, 107.68; tubes, 1,108.73; total, 1,216.41 square feet.

The cylinders are 18 in. in diameter and 26 in. stroke; they are placed inside, and the valves are worked by Joy's gear.

The driving wheels are 5 ft. 8 in. in diameter, and the bearing or radial wheels 3 ft. 7⅝ in. The total wheel-base is 24 ft. 4 in., divided as follows: Forward radial axle to coupled axle, 7 ft. 10½ in.; coupled axle to main driving axle, 8 ft. 7 in.; main driving axle to rear radial axle, 7 ft. 10½ in.

The weight of the engine in full running order is carried as follows: On forward radial axle, 30,240; on coupled axle, 39,200; on main driving axle, 31,920; on rear radial axle, 25,760; total, 127,120 lbs. The tanks will hold 1,340 gallons of water, and the fuel box two tons of coal.

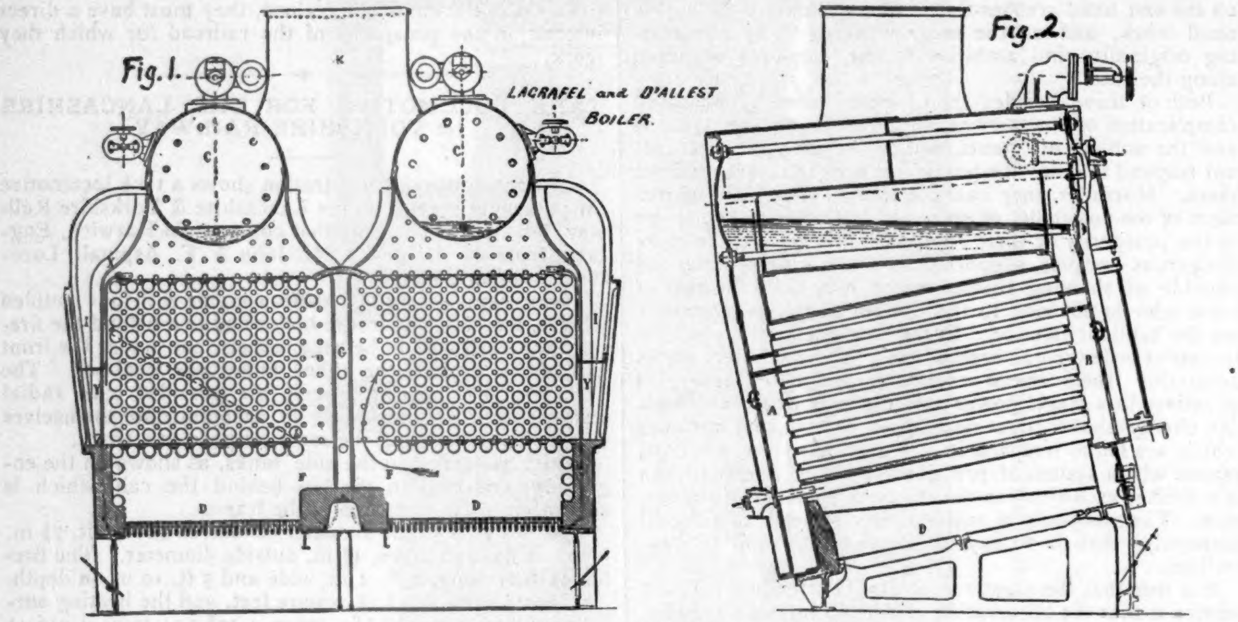
TUBULOUS BOILERS.

IN the articles on Tubulous Boilers, which were published in the JOURNAL for July last, page 319, and for August, page 346, several of these boilers were described and illustrated. These are supplemented below by descriptions of two more steam generators of this class, taken from the latest issue of the Bureau of Naval Intelligence.

THE LAGRAFEL & D'ALLEST BOILER.

This boiler is shown herewith, fig. 1 being a cross section and fig. 2 a longitudinal section. It consists of two plain flat-sided water-chambers, forming the front and back of the boiler, securely braced by numerous stay-bolts and the two connected by tubes. Above the tubes they are again connected by a cylindrical drum, in the lower part of which is the normal water-level, and the upper part

of which is the steam space. The whole is placed over the grates in an inclined position, the front being higher than the rear. The tubes are expanded against the tube-sheets, but not beaded over. Opposite each end of each tube there is a hole in the outer shell, sufficiently large to admit of the withdrawal and replacement of the tubes, closed by the ordinary plate and crow's-foot when the boiler is ready for use. At one side of the furnace the tubes are omitted, forming the combustion chamber. Over the lower row of tubes is placed a floor of fire-brick forming the crown of the furnace, and over the upper row a similar floor dividing the tube box from the space underneath the drum. The hot gases thus pass to one side of the furnace, up among the tubes, in a direction parallel to the front of the boiler, then up underneath the drum, in a reverse direction, to the smoke pipe. At the exit side of the tube-box a hanging baffle-plate prevents the escape of the gases at the top, and forces them to pass among the lower tubes.



THE LA GRAFEL & D'ALLEST BOILER.

The results obtained in a six-hour trial with this boiler are shown in the accompanying table:

Draft.	Pounds Coal per Sq. Ft. of Grate per Hour.	Pounds Water Evaporated per Pound of Coal.	Draft.	Pounds Coal per Sq. Ft. of Grate per Hour.	Pounds Water Evaporated per Pound of Coal.
Natural...	10.24	10.67	Forced....	30.72	8.82
"	15.16	9.58	"	40.96	8.89
"	15.36	9.23	"	51.20	8.43
"	15.57	9.04	....	.....	...
"	20.48	9.45	...	.....	....

In a double boiler, as shown in the sketch, the combustion chamber is common to both.

THE BARTLETT BOILER.

This boiler is shown herewith, fig. 3 being a half front view; fig. 4 a half cross section; fig. 5 an elevation, with the front end broken away to show the interior; fig. 6 a plan of the wing chambers; figs. 7 and 8 details of the tubes and brick lining.

The boiler consists of an upper chamber, U-shaped in section, from which are suspended by 4-in. water-tubes two other chambers, one on each side of the grate. Through these water-tubes pass 2-in. fire-tubes, connecting the spaces below the side chambers with the space above the upper chamber. In this upper space is also placed the steam-drum, connected on both sides with the upper ends of the U-shaped chamber by short horizontal 4-in. tubes, through which and the drum pass the 2-in. tie-rods holding together the legs of the U. As is customary with all boilers of this general type, there is a downcast pipe connecting the lower part of the drum to the side chambers. Just beneath the steam-drum, extending the entire length of the boiler from front to rear, is the feed-pipe, formed of two concentric pipes terminating in a spherical chamber outside the boiler shell. The feed-water enters through the inner pipe, and is heated to the temperature due to the pressure carried during its passage to the spherical chamber, where separation of the solid matter and extraction of the grease takes place. It then returns through the annular space between the two pipes to the front of the boiler, where it passes down an outside pipe, and enters the downcast pipes just above their junction with the side chambers.

The bottom of the upper chamber forms the crown of the furnace. The products of combustion pass among the tubes to the outer shell, thence down to the spaces below the side chambers, thence up through the fire-tubes to the uptake, in which the steam-drum is situated and around which the hot gases pass on their way to the smoke-pipe. The steam-drum is fitted with baffle-plates and a dry-pipe, and all flat surfaces are securely braced with socket or screw stay-bolts.

AERIAL NAVIGATION.

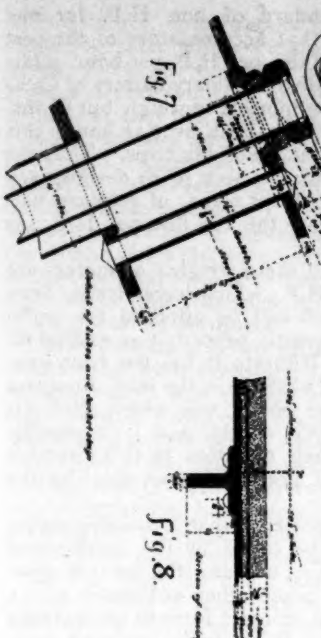
BY O. CHANUTE, C.E., OF CHICAGO.

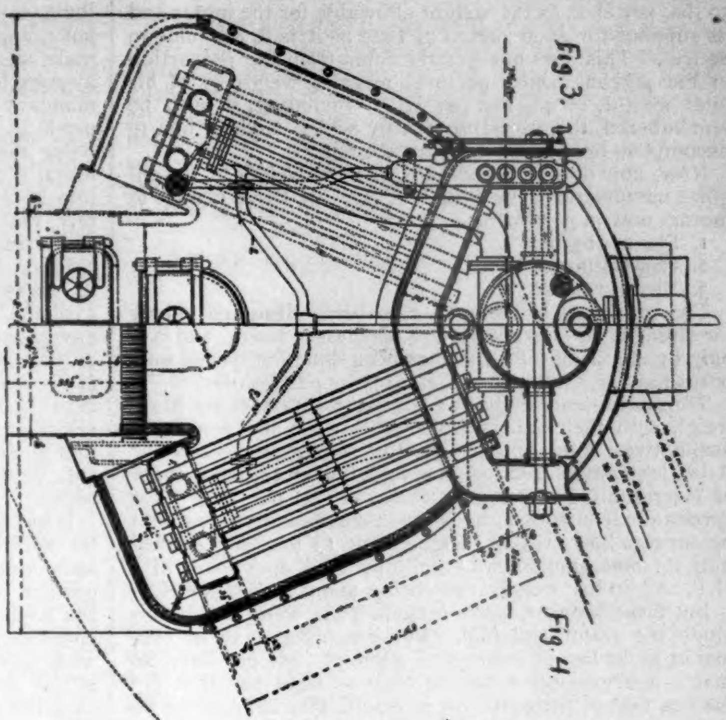
(A lecture to the students of Sibley College, Cornell University; delivered May 2, 1890.)

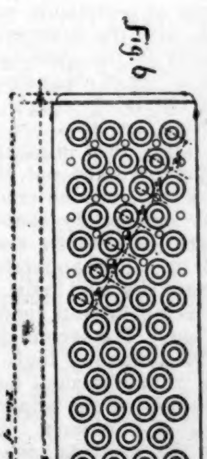
(*Concluded from page 444.*)

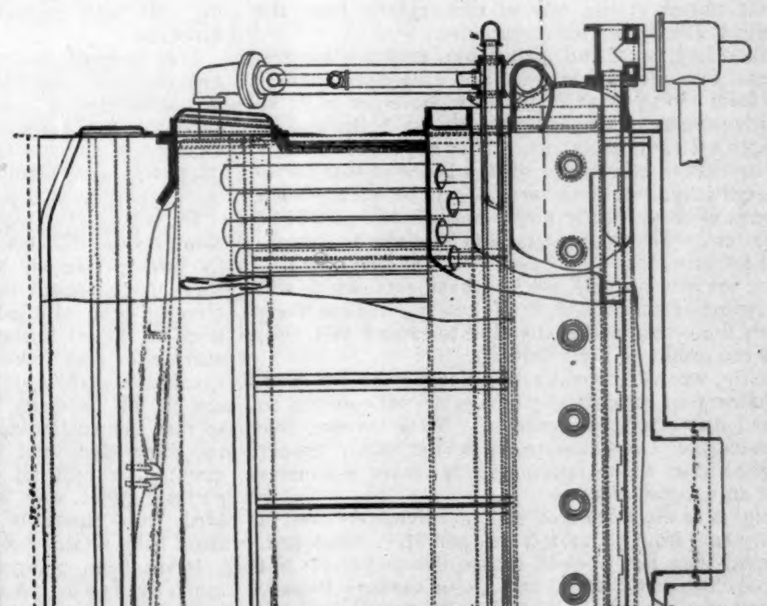
PART II.—AVIATION (*Continued*).

THIS brings up the question of possible motors, and if we confine ourselves for the present to 25 miles per hour, and assume the power required at 10 H P. per ton of apparatus, we see at once that only a fraction of that weight can be devoted to the motor. Let us assume, and I think this is not far wrong, that only one-quarter of the weight can be apportioned to the motor and its supplies; the remaining three-quarters being required for the weight of the framing, the aeroplane surfaces, the various appurtenances, and the aeronauts, we then have but $\frac{2000}{4 \times 10} =$









THE BARTLETT TUBULOUS BOILER.

50 lbs. per H.P. as the weight allowable for the motor and its supplies for such period of time as it is to consume in its trip. This does not greatly differ from the proportion in the pigeon, whose pectoral muscles weigh $\frac{1}{15}$ of his total weight, or 46½ lbs. per H.P., including, it must be remembered, the stored-up energy which enables him to accomplish long flights without alighting.

Now, how does this compare with the weight of the engines manufactured by man? There are three classes of motors now in general use:

1. Steam-engines.
2. Gas-engines.
3. Electric motors.

The machines in common use, being designed chiefly for strength and durability, are needlessly heavy, and it is only by inquiring into what has been done for special purposes that we shall get an idea of their possibilities.

Thus as to steam-engines: Ordinary stationary machines weigh with their boilers from 500 to 1,600 lbs. per H.P.; locomotives, from 200 to 300 lbs.; marine engines for Atlantic steamers, 480 lbs., and light launch engines—those of Herreshoff, for instance—some 60 lbs. per H.P. For aeronautical purposes, however, a steam-engine was built by Stringfellow, which weighed but 13 lbs. and exerted 1 H.P., and another was built by Moy and Schill of 3 H.P. and 80 lbs. weight, thus being about 27 lbs. per H.P.

But these weights, while including the boiler, do not include the water and fuel. These supplies may be estimated at 22 lbs. of water and 4 lbs. of coal per hour, so that if a large engine can be built as light per H.P. (13 lbs.) as that of Stringfellow, it would still need, if for so short a trip as two hours, 52 lbs. of supplies per H.P., making a total of 65 lbs., including the engine itself.

The principal weight is that of the water. It has been proposed to utilize part of this over and over again, by equipping navigable balloons with surface air condensers, but the difficulties in the way of this, chiefly from the added weight, are almost insuperable.

Next, therefore, gas and petroleum engines suggest themselves. As now made they are excessively heavy, weighing from 280 to 1,000 lbs. or even more per H.P., so that the advantages of dispensing with the boiler and its water supply are completely lost. They are comparatively of recent invention, however, and it is believed that corresponding reductions of their weight can be made,* such as have been effected for the steam-engine, and as will be seen hereafter for electric motors, and that this is a promising field for experiment; for even if aerial navigation be an Utopia never to be realized, improvements which will permit a reduction in the weight of gas-engines are likely to cheapen their cost materially, and to extend their use, as well as the profits of their builders.

And, lastly, we will consider the electric motors, with which whatever of success the navigable balloon has so far attained has been accomplished. They involve, like the steam-engine, two separate parts, the motor proper and the generator, which latter may be either a primary battery or an accumulator.

The weights of the motors or ordinary dynamos used in this country run from 92 to 260 lbs. per H.P. developed, while abroad they run from 68 to 350 lbs. per H.P.; but the special dynamo used by Commandant Renard weighed but 26.4 lbs. per H.P., and a very small one, built of aluminium by M. G. Trouvé, weighed at the extraordinary rate of but 7.7 lbs. per H.P.

M. Trouvé is now building for the Portuguese Government a 10-H.P. dynamo, which will weigh less than 220 lbs., and which is to be used to drive a navigable balloon. The total weight of the motor, batteries for several hours of work, screw and accessories, is estimated at 1,496 lbs., or at the rate of 149.6 lbs. per H.P. developed.

Contrary to expectation, accumulators are found, by comparison of numerous data from various makers, gathered by M. Tissandier, to be actually heavier than primary batteries. As they are charged to last various periods of time, it is necessary, in order to compare them, to reduce them to the common standard of one H.P. for one hour, and it is then found that accumulators of the best make weigh from 107 to 162 lbs. per H.P. per hour, a fair average being 135 lbs.; while the primary battery of Commandant Renard is stated by himself to weigh but 66 lbs. per H.P. per hour, and to last a little over 1½ hours, this being the present possible length of his trips. Thus the motor of the air-ship *La France* is seen to be decomposed into 26.4 lbs. of dynamo and 103.6 lbs. of primary battery, making in the aggregate the 130 lbs. per H.P., as has already been mentioned.

It will be observed that all these weights of motors are in excess of the 50 lbs. per H.P., which have already been assumed as the weight which can be afforded for aerial navigation, and yet not so greatly beyond it as to shut off all hope of improvement. Hitherto it has not been generally realized that the chief obstacle in the way of success is the want of a light motive power, one which shall develop great energy with little weight, and it is possible that when inventors turn their attention in this direction still lighter motors than at present known shall be the result.

It has been suggested repeatedly that a suitable motor for aerial navigation may be found by the invention of some kind of explosive engine, utilizing the force of gunpowder, nitro-glycerine or some other substance which can be flashed from the solid or liquid form to the gaseous condition; but such a motor is yet to be invented, and, what is more difficult, regulated and perfected. Attempts in this direction, notably with gunpowder, actually antedate the steam engine, but the difficulties of controlling power so intense and so rapidly generated have hitherto been found too great to be overcome. It would be rash to say that they cannot be, although true explosive engines have thus far exhibited an unpleasant irregularity of working, frequently giving deficient strokes, but at times coming out with powerful explosions which may kill the inventor.

It is believed that gas or petroleum engines, which are also explosive engines, with the difference that the working substance is already in the gaseous form, and thus subject to fewer irregularities of expansion, present greater chances of success in obtaining a light motor for aerial purposes, and would-be inventors are advised to turn their attention in this rather than in other directions.

But even if the motor is worked out, there will remain some serious difficulties to be encountered before man can fly through the air at satisfactory speeds. The first of these is the requirement for absolute stability which has already been alluded to. The apparatus must balance itself in the air automatically, and must possess sufficient surface to come down as a parachute should the machinery break down while sailing. The second difficulty will consist in the necessity for obtaining high initial velocities, so that the sustaining pressures shall be great, and that the dimensions and weight of the apparatus may consequently be reduced to a minimum. This difficulty of getting under way is the principal one encountered by birds, and probably furnishes the reason why none of them have attained the size of land and marine animals.

It has been pointed out that there are no flying birds much over 30 lbs. in weight, and, reasoning from analogy, it has been argued that man cannot hope to improve upon nature in this direction; but not only are birds much more complicated in structure than a flying machine needs to be, having many functions to perform (such as wing-folding, feeding, reproduction, etc.) besides that of mere flight, but they evidently expend much more energy in starting than in any other portion of their evolutions.

The smaller ones jump from the ground into the air with all their might, and then beat their wings with much greater rapidity and amplitude than in their normal flight. If rising vertically they soon exhibit signs of distress. The larger birds in starting from the ground are compelled to run considerable distances, always against the wind, in order to gather headway and supporting power, and even with the most energetic flapping they cannot rise at a steeper angle than 45°. All birds prefer to start from a perch, for by directing their first course downward they gather velocity from the action of gravity; at times some

* Since reading this lecture, the Author has seen an account of a three-cylinder petroleum engine built for marine purposes, in France, which develops 5 H.P., and weighs but 440 lbs., thus being in the ratio of 88 lbs. per H.P. It consumes, as near as may be, 1 lb. of petroleum per H.P. per hour.

of the larger ones obtain relative velocity by simply spreading their wings wide open to the breeze while yet on the perch, the object in every case being to avoid the great exertion required to obtain speed, for once fairly under way they are masters of their movements.

Resort to some equivalent devices will evidently be open to flying machines, but it is evident that until the question of stability has been thoroughly worked out, such experiments will be exceedingly dangerous; no such apparatus has yet succeeded in raising itself from the ground with the whole of its motive power, and the most that can be said at present is that recent elucidations of the laws of flight seem to indicate that it is not impossible for man to succeed with an aeroplane.

There are probably scores of shapes which can be made available for such machines, just as there are hundreds of forms of birds who display various peculiarities in their flight; but in every case there will be the same requirements as to a light motor, absolute automatic stability and some device for gaining initial velocity, as well as for landing safely. This will require much experimenting, and a beginning has scarcely been made, so that even granting the accomplishment possible, the working out of the problem may prove to be slow.

Success might be much hastened, however, by a working association of searchers in this field of inquiry, for no one man is likely to be simultaneously an inventor, to imagine new shapes and new motors; a mechanical engineer, to design the arrangement of the apparatus; a mathematician, to calculate its strength and stresses; a practical mechanic, to construct the parts, and a syndicate of capitalists, to furnish the needed funds. It is probably because the working out of a complex invention requires so great a variety of talent, that progress in other fields has proved so slow, several generations sometimes passing before an important invention such as that of the steam-engine, the telegraph, or the reaping machine is finally perfected and brought into general use.

I have refrained in this paper from discussion of the various mathematical formulæ concerning air resistances, because not only are they a matter of controversy, which must hereafter be settled by experiment, but also because the figures of M. Drzeweiki, which are based on empirical formulæ, may be in need of revision; for the benefit of the curious in such matters, however, it may be stated that his papers can be obtained (in French), as they are in print.

CONCLUSION.

To sum up, therefore, the present "State of the Art"—if it has yet progressed sufficiently to be called an art—may be stated as follows:

A measurable success has been attained with navigable balloons. They have been driven 14 miles per hour, and it is probable that speeds of 25 to 30 miles an hour, or enough to go out when the wind blows less than a brisk gale, are even now in sight. Very much more speed than this is not likely to be obtained with balloons, for lack of sufficiently light motive power, and because of unmanageable sizes.

Much greater speeds can perhaps be attained eventually with aeroplanes; recent investigations indicate this; but even a beginning is prevented by the lack of a light motor, and by questions as to the stability of the apparatus as well as to safe ways of gaining high initial velocities. Whether these difficulties will ever be overcome no one knows, but they indicate the direction for investigation and experiment, while the probable benefits to man of a solution of the problem are so great that they are well worth striving for.

Success with aeroplanes, if it comes at all, is likely to be promoted by the navigable balloon. It now seems not improbable that the course of development will consist, first, in improvements of the balloon, so as to enable it to stem the winds most usually prevailing, and then in using it to obtain the initial velocities required to float aeroplanes. Once the stability of the latter is well demonstrated, perhaps the gas-bag can be dispensed with altogether, and self-starting, self-landing machines substituted, which shall sail faster than any balloon ever can.

If we are to judge of the future by the past, such improvements are likely to be won by successive stages, each fresh inventor adding something to what has been accomplished before; but still, when once a partial success is attained, it is likely to attract so much attention that it is not impossible that improvements will follow each other so rapidly that some of the present generation will yet see men safely traveling through and on the air at speeds of 50 or 60 miles per hour.

BRIEF NOTES ON INDIAN RAILROADS.

By George L. Cumine, C.E.

It must be understood that the present article does not pretend to give any detailed account of the railroads of India, but is simply a series of notes taken on a trip from Calcutta across India to Bombay.

The principal railroad of Bengal is the East Indian, which runs up the fertile basin of the Ganges, and at Allahabad, 565 miles, is only 300 ft. above sea-level. There it forks, extending southwestward about 230 miles to Jubbulpore—elevation, 1,300–1,400 ft.—and northwestward to Delhi, which is 800 ft. above the sea and 955 miles from Calcutta.

Through trains to Bombay run from Jubbulpore to their destination over the Northeast Extension—616 miles—of the Great Indian Peninsula, of which road the southeastern arm reaches from Bombay *via* Poona to Raichur, about 440 miles, on the way to Madras. Both arms attain, within 100 miles of Bombay, an altitude of nearly or quite 2,000 ft.

The Bombay & Baroda runs from Bombay about due north to Ahmedabad, 309 miles.

All these are broad-gauge (the first two mentioned with a large percentage of double track), laid with rails of the English pattern, carried in cast-iron chairs, either on timber cross-ties or cast-iron sleepers. In the latter case chair and sleeper are cast together, and the gauge is maintained by a light-looking wrought-iron tie. The ballast is rock. For new joints plates deeper than the ordinary strap seem to be in favor, and on the East Indian I noticed some plates with six bolts; but the joint question does not seem to have produced as many competing designs here as with you. All joints are suspended and opposite.

Keys are invariably outside the rails. On the Great Indian Peninsula I noticed cylinders of coiled steel ribbon substituted on some stretches for wooden keys. The 2.7 per cent. grade on the road is laid with timber ties and heavy four-hole chairs, like the English main lines.

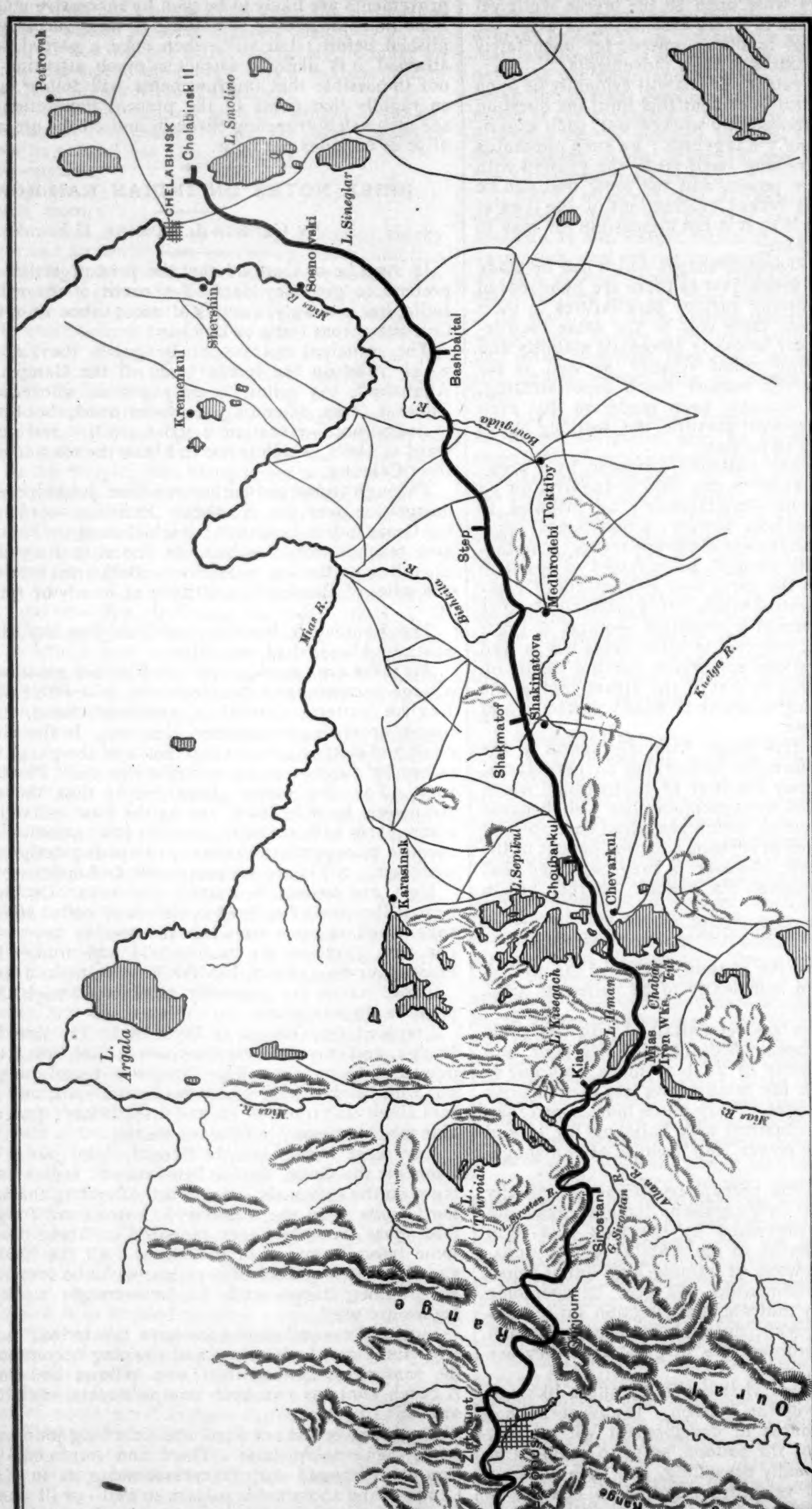
These tracks are generally excellent, though the joints pound a little in places.

I crossed the Ganges at Benares by the fine Dufferin Bridge, and traveled over the Oude & Rohilkund to Lucknow and Cawnpore. This is also a broad-gauge road, but with brick ballast under flat-footed rails, and the less said about that track as I found it the better; for considerable stretches every joint was a battle.

Very easy curves and, in Bengal, light grades prevail. Even on the Great Indian Peninsula 6° seems the maximum on the extremely heavy work attending the ascent of the Ghauts. On the Bombay & Baroda are freight and third-class passenger cars mounted on three axles, with some lateral traverse in the boxes. All the East Indian and Great Indian Peninsula cars seem to be four-wheeled. Metal under-frames and, for new freight stock, metal bodies are used.

First and second-class cars have lavatories; occasionally (first-class) bath-rooms and sleeping accommodation, the passengers finding their own pillows and covering. A coach contains two such compartments, each with its own toilet-room.

The lower berths are fixed, and on a long journey do not prove comfortable seats. Third and intermediate class cars are arranged with transverse seats, as in England. Lamps of the abominable pattern so well—or ill—known in Europe are universal here. At 40 miles an hour these four-wheelers sometimes knock about very unpleasantly, but that speed does not seem very often attained. All passenger stock has double roofing, carried down the sides



THE ZLATOOUST-CHELABINSK SECTION, SIBERIAN RAILROAD.

DISTANCE FROM ZLATOOUST TO CHELABINSK, 156.25 VERSTS = 103.5 MILES.

and ends a foot or more. Side buffers and ordinary English couplings are used on the broad gauge.

Motive power looks much as in England. Six-connected inside engines for freight, and for passengers eight-wheelers, four-coupled, with leading truck and—except on the East Indian—inside cylinders are generally used. On the Oude & Rohilkund I saw some eight-wheel engines with inside cylinders driving an intermediate shaft, on which were outside cranks bearing in the side-rods; these had been originally all-coupled, but the front lengths of the side-rods, right and left, had been taken down. Apparently these are not being imitated.

Continuous brakes are not much in evidence yet, though one sees the vacuum fittings on some engines.

Speeds are very low; for instance, the mail across India only averages about 23 miles per hour.

The Thull Ghaut, on the northeast arm of the Great Indian Peninsula, has a switchback at about 1,000 ft. elevation; up to it the maximum grade is 1.67 per cent.; from the switchback the remaining 900 or 1,000 ft. is attained on a 2.7 per cent. grade, whether equated or not I do not know. Over this trains of about 20 cars are worked by a pair of eight-connected tank engines and four "incline brake vans"; ascending there is an engine at front and rear, but descending both are in front.

I came from Delhi to Ahmedabad over the Rajputana-Malwa State narrow-gauge road, which with the broad-gauge Bombay & Baroda forms the Bombay, Baroda & Central India. The track, of flat-footed rails spiked to timber ties in rock ballast, was excellent. Although attaining considerable altitude, I saw no grades exceeding 40 ft. per mile and no sharp curves. The stock is generally four-wheeled, but double-truck and six-wheel flexible-base freight cars are also in use. The engines look big for the gauge, and have generally outside frames, often with inside cylinders. The road has iron and masonry bridges, and flat, occasionally stone-pitched, slopes. Metal and stone fence posts, signal posts and telegraph poles are characteristics of the various roads I have mentioned. These, combined as they are with good ballast and careful drainage, must keep the cost of maintenance and renewals low.

Passenger fares are wonderfully low in India, ranging, apparently, from 9, 8 or 7 rupees for first class to 1½ to 1 rupees for third-class per 100 miles; the second-class fares are half the first, and many Europeans travel second. Value of the rupee is anything between 33 cents and 45 cents American currency.

Freight rates are also fairly low, apparently; for long hauls of coarse freight on the East Indian about ½ anna per ton-mile. Sixteen annas go to the rupee.

Passengers appear to afford about one-third of the gross receipts on the Great Indian Peninsula and quite one-half on the East Indian; the proportion of first and second class being very small indeed.

The Government loses on the railways only on account of the depreciated rupee.

Interest on the borrowed capital being guaranteed at about 4½ per cent., the actual payments amount to about 7 per cent. Indian currency, and this the railroads fail to produce by 2 per cent.

Old rails are put to many uses here, as, for instance, telegraph and fence posts, roof trusses, floor beams in buildings and open culverts, etc.

One notices a marked absence of guard-rails on the smaller structures. Probably derailments are comparatively infrequent, owing to the excellent track and low speeds.

Baggage registration is universal. The free allowance to first-class passengers is 100 lbs., and decreases about as the fares for the other classes.

As to other Eastern countries, I may say that there is a little railroad work doing now in the Malay Peninsula, but information is not easily obtained. The Dutch continue to take rails in Deli (Sumatra), principally, I think, for plantation roads.

Robert Gordon is still in Siam in the Government service, also a Mr. Bethje from, I believe, Krupp's establishment. I am afraid there will be no orders of moment for either Krupp or any one else for some years from Siam. According to later advices, Mr. Gordon has left Siam.

THE BEGINNING OF THE GREAT SIBERIAN RAILROAD.*

BY A. ZDZIARSKI, ENGINEER.

THE Oufa-Zlatooust Railroad, described in the previous article, was opened in September last; but it was some time before decided to begin the construction of its extension, the Zlatooust-Chelabinsk Railroad. The survey and location of this line was made in 1888; and work on the first 40 miles was begun last summer.

According to the survey the length of this line is 156.25 versts, or 103.5 miles. Starting from Zlatooust the line first rises along the western slope of the Oural Range for 10 miles; then reaching and passing the summit descends the eastern slope of the range along the valleys of the Little and the Great Sirostan, crossing both those rivers many times; then crosses the divide between the Great Sirostan and the Mias River. Crossing the Mias the line continues to descend the eastern slope of the Oural, passing near Lake Ilmen, then between Lakes Kisegach and Chonbarkul into a fairly level steppe or prairie region. Crossing the Bishkila and the Birgilda—both tributaries of the Mias—it finally reaches the district town of Chelabinsk, situated on the Mias, a tributary of the Irtish, which is in its turn a tributary of the Obi.

From this it will be seen that at Chelabinsk the road is fairly across the Oural and in the Great Siberian plateau.

Of the 103½ miles of the road, about one-half was located in a difficult mountain country; the other half is over a level country, where the location was comparatively easy.

The estimated cost of the road is 7,954,378 roubles, or 76,854 roubles per mile. As before explained, it is difficult to express this in American currency, but an approximation would be $37,500 per mile.

The general designs for road and equipment are the same as for the Oufa-Zlatooust Railroad. The grade and bridges are for a single track, and sufficient sidings are provided to permit the running of nine trains daily in each direction. The water supply is sufficient for 12 trains daily each way; but at first the equipment of motive power and rolling stock will be sufficient only for one mixed train and one freight train in each direction daily.

The earthwork on the line is not easy, the average quantity being 67,000 cub. yards per mile; about half of all the excavation is in rock, more or less hard.

The water crossings are all masonry arch culverts or iron bridges. The culverts are 68 in number and vary in span from 3½ ft. to 21 ft. The bridges all have iron superstructure on masonry abutments, and are 97 in number, as follows: 66 of 7 ft. span; 27 of spans from 14 to 56 ft.; 2 of 70 ft.; 1 of 105 ft.; 1 of 210 ft. span. The total weight of iron in the bridges is about 1,000 tons.

The rails are of steel, 65½ lbs., of Russian manufacture, and the pattern of rails, the ballast, etc., are the same as on the Oufa-Zlatooust road.

The buildings also are of the same pattern as on that road, wood on stone foundations. The smaller ones include 58 watchmen's houses and 25 section-houses; 15 of the latter are at stations and 10 at points between stations. There are 76 road crossings, each protected by a gate and watchman.

The station buildings are eight in number, one being of the second class, one of the third, three of the fourth, and three of the fifth class. The three engine-houses have nine stalls in all. For the water supply of eight stations there are required seven pumping engines, which vary from 4 to 10 H.P.

There is at the terminus a large turn-table of the Sellers pattern, and a weighing bridge. The station equipment requires 75 switches; 16 green signal disks; 16 semaphores, of wood; 35 stop-blocks and 25 switch-houses.

The motive power at first consists of 10 locomotives of the standard eight-wheel or freight pattern. These weigh 42 tons, empty. Cars will be supplied from the connecting line.

* See previous articles on the Great Siberian Railroad in the JOURNAL for June, 1890, page 258, and for September, 1890, page 397. The location of Chelabinsk, etc., will be seen on the map of Siberia on page 259, June number.

As to the estimated cost, it will not be without interest to give a detailed statement of the distribution to the different works on the road; and such a statement will be found in the accompanying table.

No.	Description of Work.	Cost in Roubles. Total.	Cost in Roubles. Per mile.	Per cent. of Total.
1	Expropriation of lands, etc.	105,600	1,020	1.3
2	Earthwork	2,463,732	23,804	31.0
3	Bridges	1,675,230	16,186	21.1
4	Track	1,701,482	16,440	21.4
5	Road accessories	22,066	213	0.3
6	Telegraph line	39,857	385	0.5
7	Road buildings and gates	143.550	1,387	1.8
8	Station buildings	401,150	3,876	5.0
9	Water supply	129 710	1,253	1.6
10	Station accessories	117,950	1,140	1.5
11	Rolling stock	349,650	3,378	4.4
12	General expenses	583,256	5,635	7.3
13	Extraordinary expenses	78,145	755	1.0
14	Controlling and police	61,000	590	0.8
15	Sundries	82,000	792	1.0
	Total	7,954,378	76,854	100.0

The item of track is made up as follows: Rails, 953,520; fastenings, 176,889; ties, ballast and tracklaying, 571,073; total, 1,701,482 roubles, as in the table.

CONTINUATION OF THE ROAD.

The first section of the Great Siberian Railroad, as just described, ends at Chelabinsk, a district town situated just beyond the geographical boundary between Europe and Asia—the Oural Mountains—but still within the administrative or political boundaries of European Russia.

From Chelabinsk the railroad may be continued to Ekaterinburg, a distance of 133 miles. That town is a main point on the Oural Railroad, which extends from Perm on the Kama River to Tumen on the Toura, and thus connects the watershed of the Volga—to which the Kama is a tributary—with that of the Irtish and the Obi. As the Oural Railroad has its eastern terminus at Tumen, there is, in summer, a connection with the important town of Tomsk by boats on the Toura, Irtish and Obi rivers.

On the other hand, should the opinion of M. Mejeninov, as to the necessity of a continuous railroad line, prevail, Chelabinsk will be the starting point for the Central Siberian Railroad.

The location of such a line from Chelabinsk to the Tom River will not be difficult, the country being generally level. From Chelabinsk it would go eastward to Kourhan and there cross the Tobol River; then through Petropavlovsk on the Ishim to Omsk, where it would cross the Irtish. From this point it would follow up the right bank of the Om River to Kaïnsk, then take the line of the post road to Kolivan and, crossing the Obi between Kolivan and Doubovinska, ascend the divide between the Obi and the Tom, crossing the latter about 50 miles from Tomsk; that town could best be connected with the main line by a branch. From the crossing of the Tom the road would go directly to Mariinsk, which is a point on the line already located for the Central Siberian Railroad, starting from Tomsk.

In the mean time, however, the railroads have been located to connect the various sections already provided with water communication. These locations must form the subject of another article.

UNITED STATES NAVAL PROGRESS.

One of the questions which will soon have to be discussed and settled in connection with the new Navy is that of sheathing steel ships. So far, none of the new vessels have been sheathed, and the rapid fouling of bottoms has seriously affected the speed of the new cruisers. Neither the *Charleston*, on her recent trip to Honolulu, nor the *Baltimore*, on her voyage to Stockholm, showed the speed expected of them, and the condition of their bottoms was undoubtedly the cause. The expense of docking and cleaning a large ship is considerable, but under present conditions and regulations this process will have to be gone through twice every year.

The question has been much discussed in England, also, and ships have been built there in both ways, but it cannot be said that any fixed rule has been adopted. This matter was ably discussed by Naval Constructor Hichborne in a paper read before the Naval Institute last year.

CONTRACTS FOR NEW SHIPS.

The bids received at the Navy Department for the three new battle-ships and for Cruiser No. 12 were opened October 1, according to previous notice.

For the battle-ships four bids were received, as follows:

1. The William Cramp & Sons Ship & Engine Building Company, Philadelphia, offered to build one battle-ship on the Department plans for $2,990,000, or two for $2,890,000 each; one battle-ship on their own plans for $3,120,000, or two for $3,020,000 each. As to their own plans, the following statements were made in the bid:

The Navy Department's scheme, plans and specifications for hull and machinery are adopted. We propose to add 12 ft. to the length of the vessel, increasing the displacement, when at the same normal draft of 24 ft., by 480 tons, utilized as follows: Additional length of the hull and armor about 197 tons, the balance, 283 tons, to be utilized at the Department's discretion in supplying additional side-armor plating 3 in. in thickness, forward and abaft, extending the present 18-in. armor-belt from the berth deck to just above the protective deck, and in providing an additional thickness to the armor around the guns. The construction of hull and machinery, arrangements of decks, quarters, fittings, etc., disposition of battery, types and dimensions of boilers, etc., will be upon the Department's plans and specifications.

The advantages of these additions to the Department's design are as follows:

First. Much better protection to the underwater ends, as the 3-in. armor on the ⅝-in. plating now there will be sufficient to break up high explosives, and in conjunction with the belts of cellulose now along the slopes of the protective deck will prevent the entrance of water to these places.

Second. Greater proportionate length of armor-belt, leading to a large protected water-line area, reducing the sinking when the ends are riddled or blown away by heavy shells, and so preserving a greater height of armored free board.

Third. Greater stability with riddled ends.

Fourth. Greater coal capacity.

Fifth. Even with the 3-in. armored belt, above referred to there will be a number of tons of surplus buoyancy which can be utilized in increasing the thickness of the protection to the 6-in. and 8-in. guns.

Sixth. The 3-in. plating will greatly strengthen the ram-bow, and afford increasing protection to the steering gears.

Seventh. The greater length will add to the power of keeping up speed against head seas.

2. The Bath Iron Works, Bath, Me., bid for one battle-ship on the Department plans at $3,149,000.

3. The Union Iron Works, San Francisco, offered to build one battle-ship for $3,240,000, or two for $3,200,000 each.

4. The Risdon Iron & Locomotive Works, San Francisco, offered to build one battle-ship for $3,275,000.

For Cruiser No. 12—the three-screw protected cruiser of 7,300 tons—two bids were received, as follows:

1. The William Cramp & Sons Ship & Engine Building Company, on the Department plans, $2,725,000.

2. The Union Iron Works, San Francisco, also on the Department plans, $3,025,000.

The plans for the battle-ships were described and illustrated in the Journal for September, page 392; those for Cruiser No. 12 in the Journal for October, page 446.

The contract for Cruiser No. 12 was awarded to the Cramp Company at their bid of $2,725,000.

For the battle-ships the Department decided to adopt the alterations proposed by the Cramps, lengthening the ships 16 ft. and increasing their displacement about 700 tons. On this basis the contract for two of them was awarded to the Cramp Company at $3,066,666 each, and that for the third one to the Union Iron Works at $3,226,667, the price being adjusted to meet the additional size.

The additional displacement given these ships will be utilized by putting on some additional armor protection.

Bids have been asked for three more new vessels, the

Ammen harbor-defense ram, the torpedo gun-boat of 750 tons displacement, and a first-class torpedo-boat. For the torpedo-boat builders will be asked to put in their own plans; she is to be somewhat larger than the *Cushing*, and will be required to reach a speed of 27 knots an hour for a short distance.

THE TORPEDO-BOAT "CUSHING."

THE following very complete and interesting description of the engines of the *Cushing* is from a paper read by Passed-Assistant Engineer Stacy Potts, U. S. N., before the American Society of Naval Engineers, and published in the *Journal* of that Society:

The hull and machinery of the *Cushing*, with the exception of the boiler, were designed by Mr. Nathaniel Herreshoff, and built by the Herreshoff Manufacturing Company, of Bristol, R. I., under the inspection of Commander George A. Converse, U. S. N. The principal dimensions of the hull are as follows: Length over all, 137.5 ft.; extreme beam, 15.05 ft.; draft, 5.2 ft.; displacement, 105 tons. She has a ram bow, overhanging stern, twin screws, and a partially balanced rudder.

The main engines consist of two sets of quadruple-expansion engines of the vertical, overhead-cylinder type, the low-pressure area being divided into two, thus making five cylinders of 11¼ in., 16 in., 22½ in., 22½ in., and 22½ in. in diameter, respectively, by 15 in. stroke of piston. They are connected by the usual rods to five cranks, which follow each other at an angle of 144°. This gives a very equal distribution of pressure, which shows itself in the very smooth manner in which the engines run and the almost total absence of vibration.

It is worthy of remark here that no water pipes are fitted for cooling off bearings, nor (with one exception) was a drop of water used on any of them in the trial trips, the exception being on one occasion when dirt got into a bearing on one of the eccentric shafts situated beneath an open hatch, which was kept from excessive heating by laying cotton waste soaked in water upon it. Each cylinder has its own valve chest inboard, each provided with a double piston valve. The main pistons and valves are packed by small cast-iron rings, and not a drop of oil is used or can be placed in either the cylinders or chests, a practice always adhered to by the builders, and which works well. The frames are of steel rods 1¼ in. in diameter, braced diagonally, and form the cap bolts of the main bearings, which in turn are secured to a bed-plate consisting of a single sheet of wrought steel ¼ in. thick, with openings cut through it for the passage of the cranks. This bed-plate is secured along its edges in a fore-and-aft direction to keelsons, also beneath the main bearings of the high-pressure and the after low-pressure cylinders, the intervening bearings having no support at all beneath, and during the highest speeds no signs of working or weakness were noticeable around this apparently weak part.

The valves are worked by cranks on a small shaft running parallel with the main shaft, and geared to it at the forward end by cut steel gear wheels; the reversing being done by partially rotating this countershaft by hand by means of a lever and spiral feathers and sleeves situated in the forward bearing. The reversing is done easily, and is practically instantaneous.

The cross-heads are of phosphor-bronze; this does away with all gibs, set-screws, keys, etc.; they envelope a couple of bar slides, the ahead bar being cast hollow and filled with water before or during a run and the water allowed to evaporate through the top. All of the oil cups are kept filled with horse hair to prevent the oil from jumping out, and are fed through pipes leading to a main tank on each engine. The main engines do nothing but turn the screws, all of the pumps being independent.

There is one surface condenser containing 1,052 sq. ft. of cooling surface; it lies low on the keel in the after end of the engine room, the tubes running fore-and-aft. The heads are conical and continue down through the bottom of the vessel about 8 in., forming a scoop for the circulating water to enter and discharge when the vessel is under way, the cooling water passing through the tubes once. The forward scoop is provided with a strainer, the after one is without, the idea being that any foreign substance that may enter the after scoop when backing would be washed out when going ahead again. Situated in the forward head are vanes 13¾ in. in diameter, forming a centrifugal pump and driven by a single vertical engine 4 in. diameter by 4 in. stroke. This engine and pump are used when the vessel has no motion through the water. When running at a speed of about 20 knots, and steam is shut off the circulating engine, the engine and pump make about 100 revolutions per minute, by the motion of the scooped water passing through it.

There are three single-acting, vertical, single-trunk, bucket air pumps for each main engine; they are 10 in. in diameter by 5 in. stroke, and are placed alongside and above the condenser; they have no foot valves, the bucket and delivery valves being flat annular rings of composition ¼ in. thick. The pumps are worked from a cast-steel shaft, the cranks being 120° apart. On the same shaft are three vertical, single-acting plunger feed-pumps 2¾ in. in diameter and 5 in. stroke. Each set of air and feed pumps is driven by two simple vertical engines 3½ in. in diameter and 5 in. stroke, and geared down 3.2 : 1. These engines are controlled by a small ball-governor, and work very well, the air and feed pumps making about 240 strokes per minute when running at maximum speed.

All of the auxiliary engines exhaust into the main condenser when not under way, and when under way into the low-pressure receivers; this increases the pressure there about 1 lb.

There are two boilers, one forward and the other abaft the engine compartment. They were built of domestic material by the Herreshoff Manufacturing Company, from drawings furnished by Messrs. Thornycroft & Company, England, and of the type used by that firm and well known. They each contain 38.3 sq. ft. of grate and 2,375 sq. ft. of heating surface, or a ratio of 1 : 60. They each weigh, empty, 9 tons, or 11 tons with water to the steaming level. The safety valves are set at 250 lbs., and the boilers have been tested to 500 lbs. per square inch.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Concluded from page 460.*)

XXI.—LAND DEFENSE—ENGLAND.

WHILE the Continental powers have, almost without exception, adopted cast-iron, steel or steel-faced armor for land fortification, England, beginning at a date when wrought iron was the only metal employed for armor plates, has up to the present time continued to use it exclusively upon her iron-clad forts. The possibility that masonry might have to give place to metal in the construction of fortifications had already been recognized before the outbreak of the American war, as shown by the experiments with metal shields, already referred to. But it required the actual demonstration of the power of rifled guns against brick and granite to make the necessity for such employment apparent.

England began the construction of iron-clad fortifications in the early sixties, and has at the present time works of this description at all important points upon the home coast and in the Mediterranean. In the English construction there are three different methods of applying armor for land defense: (1) casemate shields built into the masonry, (2) iron batteries, and (3) turrets. In the first case, which may be applied simply for the protection of the guns or upon the exposed side of a work, the armor, in three or more plates of from 5 to 10 in. in thickness, is built into the masonry, with the intervals between the plates filled in with wood or concrete. A strong iron frame is first built in and bolted to the masonry, and to this the

rear plate is secured; then each additional plate is bolted to the one next behind it. At Gibraltar, Malta and Portsmouth, where a wide arc of fire is desired, the batteries are circular in plan, and the guns, arranged on turn-tables, can fire from either one of two embrasures.

In the second class the entire walls are armored with plates of varying thickness, as in the former case, with concrete between the plates, except at the gun-ports, where wood is used. Fig. 1 gives in section a work of this kind. An important feature in the English system is the provision for increasing the thickness of armor upon an already finished work at any particular point, or for the removal of plates from one part of the structure to another. To the end that additional plates may be added, the outside plate is prepared therefor by the drilling of the necessary holes and the insertion of temporary bolts. At important sea-coast forts, as at Spithead and Plymouth, the works are planned and prepared for the subsequent addition of turrets upon their roofs. The Spithead forts can each carry five turrets above their iron-clad batteries.

Of the third class—revolving turrets—but one has as yet been constructed, and this at the end of the Admiralty Pier, Dover; this is shown in fig. 2. The wall has a thickness of 25 in., made up of three 7-in. and two 2-in. intermediate plates. The turret turns about a central steel pivot, upon a live ring of steel rollers, and is worked by steam power. It mounts two 80-ton muzzle-loading Armstrong guns, which are loaded from under the glacis by running them back and dropping the muzzles. Provision is made for the addition of extra thickness of metal, as in the case just mentioned.

The English works were constructed upon the now generally abandoned theory that a plate upon plate structure offers greater resistance to penetration than one that is solid. General Inglis, under whose supervision many of the English fortifications were constructed, holds, or then held, to the opinion that where the layers of metal are separated by narrow spaces filled with wood, cement, ordinary or, better still, iron concrete, there is greater resistance offered, more elasticity, and far less liability to crack than when the plate is homogeneous, provided that the intervals between the plates be so restricted that the head of a projectile will not have cleared the bulged or torn metal of the first plate before it encounters the face of the one next succeeding. An interval between plates of 5 in. was that generally adopted in the construction of the English forts.

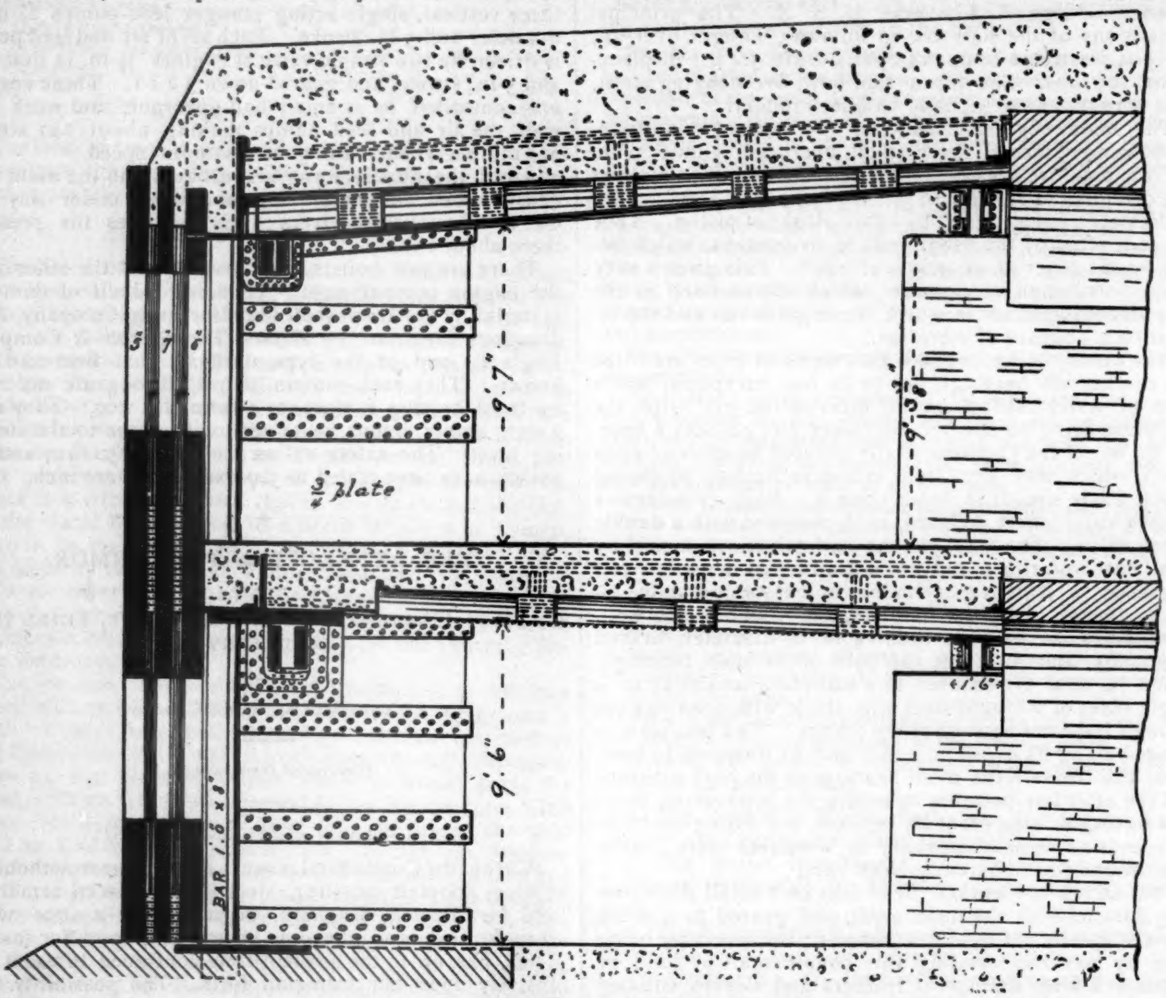


Fig. 1.

XXII.—LAND DEFENSE—THE UNITED STATES.

Plans for the use of armor-plate for land defense have as yet taken no definite shape in the United States. The first step looking to the rehabilitation of our sea-coast fortifications was taken in 1885, when, under the Act of Congress of March 3 of that year a Board on Fortifications of nine persons, with the Secretary of War as President, two civilian members and six Army and Navy officers, was appointed to report as to "what forts, fortifications or other defenses are most urgently required, the character and kind of defense best adapted for each, with reference to armament," etc.

The report of this Board was of a character well calculated to startle the average frugal-minded, easy-going citizen, whose reading had not kept pace with the enormous strides taken in the growth of modern guns and armor-clad ships, and who had not awakened to the fact of how utterly worthless were the costly piles of brick and granite standing guard upon our coasts. The estimate submitted called for an expenditure of something over $126,000,000 for forts, their armament, and auxiliary defense of submarine mines, etc. Over $100,000,000 of this expenditure was reported as urgent, while $20,300,000 was for armor-plate

alone. The defenses of New York City call for nearly $8,000,000.

The Board recommended that the shore batteries should consist of fixed or revolving turrets, armored casemates and emplacements in barbette, the latter without armor, but with their guns generally mounted upon lifts or disappearing carriages. For New York nine 2-gun turrets were recommended, with 30 guns in armored casemates.

The act of September 22, 1888, created a Board of Ordnance and Fortification, under whose supervision will come the selection of plans for the construction of forts and batteries, the details of which will be worked out by the engineers. This Board has the matter now under consideration, but, so far as known, nothing has as yet been decided upon beyond the allotment, under the recent appropriation for fortifications, of about a million and a quarter for gun and mortar batteries, of which $726,000 goes to New York, $260,000 to San Francisco, and $235,000 to Boston. No other ports have been provided for. The remainder of the seven and a quarter millions appropriated goes for the purchase of land, of guns, mortars, torpedoes, etc.

The great advance that has been made in the direction of range, accuracy and rapidity of fire of what are known as the secondary batteries of war ships will, it is believed, compel an abandonment of the scheme for open barbette batteries, and necessitate a resort to armored structures in all cases where the fire of this class of ordnance is likely to be encountered, to say nothing of the inability of earth, except in the heaviest masses, to stop the projectiles of the modern high-power rifle. The calculated penetration of the 40-cm. Krupp gun at 1,000 yards is given at 82.5 ft. in heavy clay and 49 ft. in sand mixed with gravel; that of the 6-in rifle about one-third these figures.

Fig. 3 represents a two-turreted armored structure that has been proposed for the present site of Fort Lafayette in New York Harbor.

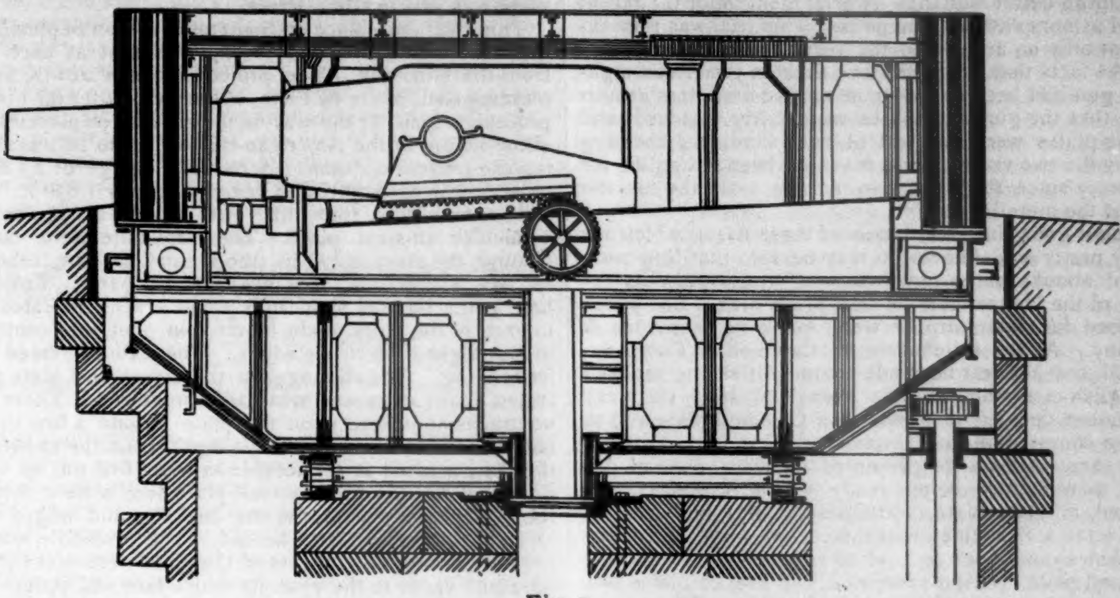


Fig. 2.

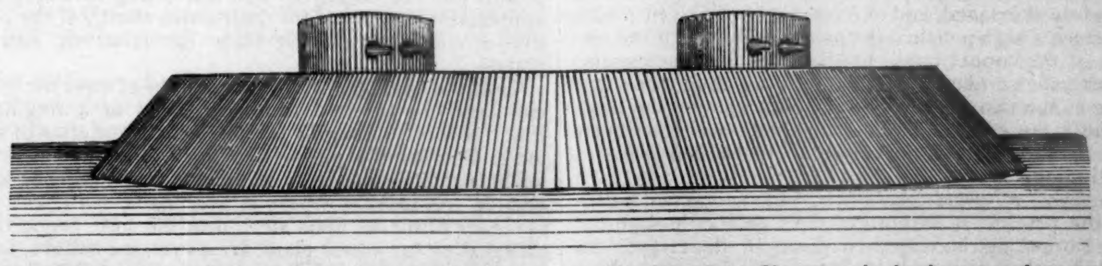


Fig. 3.

XXIII.—HOW GENERALLY EMPLOYED FOR LAND DEFENSE.

The character of the fire to which a particular work is likely to be subjected will, in a great measure, determine the material to be employed in its construction. For sea-cost works, against which the fire of the heaviest guns may be brought, but which are only likely to be called upon to endure such fire for brief periods and for a few rounds, cast iron is, no doubt, the coming metal; but for an inland fort, against which may be concentrated the prolonged and accurate fire of batteries of position, even though from guns of smaller caliber, this metal is hardly to be depended upon, and steel is likely to take its place. Although the Schumann cupola of wrought iron has been largely employed upon the Continent for inland defense, and owing to the peculiar form of the shield has given good results when subjected to fire, an equal resistance with much less weight could be obtained were steel employed instead—an important consideration.

It is, of course, no easy matter to obtain accurate information concerning the defenses of a foreign power. These matters are guarded with jealous care, and although we know the general system followed by most European powers, the same cannot be said regarding the actual disposition of works of defense. Paris, for instance, is surrounded by an outer circle of forts, with a perimeter of some 70 miles, but only in a general way have we information concerning them. So far as known they are of earth, of great profile, guns in barbette, and strengthened in some cases with revolving turrets at the salients. In Spain turrets have been proposed for the protection of Cadiz harbor, and in Portugal for the mouth of the Tagus; but no work has as yet been done in either case. Italy is constructing Grüson cupolas for sea-coast defense, and also chilled iron casemates for the forts on her Alpine frontier. Germany, Austria, Russia and Holland use Grüson chilled iron armor, principally for sea-coast defense. For inland forts the Schumann cupola is, in Germany, more generally adopted. Belgium has followed the lead of France in the use of the cylindrical wrought-iron turret. It is now proposed to substitute steel entirely for all armor-plate. It is understood that the French have under construction on their frontier one of Mougin's underground forts previously referred to, and also that Bel-

gium has likewise determined upon building works of this character.

XXIV.—CONCLUSION.

Perhaps these papers upon armor development can be ended in no better way than by brief mention of the recent tests of armor-plate at Annapolis. This trial was remarkable not only on account of the results obtained, but also from the facts that it was the first time an American high-power gun had been called upon to face first-class armor-plate; that the gun and plates were fairly matched, and that the plates were the best of their kind, representing not only the two rival systems that have been struggling for supremacy since 1877, but also a new claimant for the favor of the metallurgist.

Without going into the details of these trials, which are already pretty well known, it may be said that they were brought about not so much to test armor-plate as the quality of the Holtzer chrome-steel projectiles. The plates purchased for this purpose were made by Schneider & Company. At the solicitation of Cammell & Company, Sheffield, that the test be made a competitive one between the English compound and the French all-steel, the Navy Department decided to purchase a Cammell plate and to open the competition to all comers.

Only three plates were presented for trial—none of domestic manufacture being ready—(1) a Schneider, oil-tempered, all-steel plate, containing $\frac{1}{2}$ of 1 per cent. of carbon; (2) a Schneider nickel-steel (an alloy of 96 per cent. of steel and 4 per cent. of nickel), and (3) a Cammell compound plate, Wilson's patent. The French plates had a thickness of 10.5 in., the English of 10.6 in. These were arranged in a semicircle 30 ft. in front of the gun; were backed by 36 in. of solid oak, well braced, and supported by a bank of well-rammed earth. The gun was a 35-caliber 6-in. navy, specially made for these trials and used a 44½-lb. charge of American brown cocoa powder, and gave its projectiles a velocity of 2.075 ft., with a striking energy at the muzzle of 3,300 foot-tons. The projectiles were forged chrome-steel shell, made by the French firm of Holtzer & Company, to test which these experiments were brought about. They were 17 in. in length, and weighed 100 lbs. each.

The test was to be a shot from the 6-in gun delivered at each of the four corners, at a point 2 ft. from the horizontal and vertical edges, and a final shot from an 8-in. gun delivered in the center. The details are as follows:

Schneider All-Steel Plate.—The first shot entered the plate about three-quarters its length and there remained, apparently little injured; no cracks beyond surface fissures around shot-hole. The second and third shots penetrated the target about 12 in., the points coming through and bulging out the back; the projectiles rebounded in both cases, both slightly shortened, and one set up about 0.01 in.; both had received a high polish at the point, and both, by the restoration of the copper band, might have been fired again. The fourth shot broke up after penetrating about the same distance as the two previous shots. Except for the shot-holes and a few surface fissures, the plate was apparently uninjured, and its resisting powers almost as good as at the beginning.

The Schneider Nickel-Steel Plate.—In the first and fourth rounds the projectiles barely got their points through the plate and broke up, leaving their points in the target. In the second and third rounds the projectiles were embedded in the plate, their bases projecting about 2½ and 3½ in. from the face of the target. Beyond some splintering off of metal, where the projectiles entered, the plate was as smooth and free from cracks as at the beginning. Two bolts were started by the second shot.

The Cammell Compound Plate.—The first shot went through the plate and 11 in. into the oak backing, some bolts were started, a small piece of the steel facing broken off, and seven serious cracks opened. At the second round the projectile penetrated the plate, went into the backing and broke up, sent out cracks to the hole made by the first shot, opened the cracks already formed, and started the steel face from the wrought-iron back. The third shot went through the plate and into the backing, setting it on fire; the upper right-hand corner was a mass of cracks, which seemed to extend through the plate. At the last round the projectile went through plate, backing, earth and into the hill-side beyond, broke off about one-fifth of the steel face to a depth varying from one-third to one-half of its thickness, and cracked its whole surface. The plate was practically a wreck.

This trial took place on September 18; on September 22 the final test was had by firing one shot at each plate from the 8-in. gun. The projectile was a 210-lb. armor-piercing shell made by Firth, of Sheffield, after the Firminy process, which, by the way, is the process employed in the manufacture of the American-made shell to be tested during the present autumn. A reduced charge of 85 lbs. of powder was used, giving a velocity of only 1,850 ft.

The first shot from the 8-in. gun was against the Schneider all-steel plate. The projectile went entirely through the steel and 4½ in. into the oak backing, rebounded and broke into three nearly equal parts. From the hole made by this shot, four small cracks radiated, one to each of the holes made by the 6-in. shot, and continued in 8 straight lines to the edges. The plate remained upon its backing. The shot against the nickel-steel plate penetrated about 20 in. and was badly broken up. There were no cracks anywhere upon the plate beyond a few surface checks around the shot-holes. Apart from the shot-holes, the plate seemed as serviceable as when first put up. The final shot against the Cammell plate tore a hole through the center of the plate, the oak backing, and lodged some 12 ft. in the packed earth behind. The projectile was apparently uninjured. Pieces of the plate were sent flying a thousand yards to the rear, its entire face was stripped off to the depth of 4 or 5 in., except a few small pieces at the sides, and even these were loosened.

When taken from their backings and examined by the Trial Board, it was found that the back of the all-steel plate was in better condition than had been expected—the four cracks radiating from the central shot only extending through in places, and that the plate could still support its own weight. The back of the nickel-steel plate had no cracks except where the metal had been bulged out by the projectiles. The back of the compound plate likewise had no cracks extending through the wrought iron, except about the shot-holes.

The wood backing behind the two steel plates was not even splintered, a dent showing where the points of the shot had gone through—that of the all-steel having the better appearance. The backing of the Cammell plate was badly shattered.

A fact worthy of note is that the heat developed by the impact of the Holtzer projectile against the all-steel plate was sufficient to blister the paint upon its surface some inches from the shot-hole, clearly showing the capability of this plate of taking up and converting into heat a very appreciable amount of the destructive energy of the projectile—a claim particularly made for relatively soft steel plates.

That the coming armor-plate is to be of steel nickel alloy can hardly be asserted from the results of a single trial; that it will be thoroughly tested, the appropriation of a million dollars for the purchase of nickel ore and pig clearly testifies. The details of its manufacture are not known outside the foundry where it was made, while the exact influence of nickel upon steel, and the best proportion of nickel alloy for armor-plate, are as yet, we believe, largely a matter of theory. A fragment of the metal before us, a splinter from the point of impact, shows it to be of fine, even structure, its color indicating how thoroughly the heat developed by concussion had drawn the temper. Nickel-steel certainly seems to possess in a high degree that desideratum so long sought for in armor-plate—hardness without brittleness.

The fact that the 6-in. gun made for this trial, together with its mountings, was turned out at the Washington Gun Foundry in 55 days from the time the rough-turned forgings were taken in hand, shows how great has been the advance in gun construction since the first built-up American gun was turned over for trial in 1884 from these shops.

The battle between the gun and the armor-plate has been going on for more than 30 years. From the 4½ in. iron armor of the *Warrior* to the 18 inches of tempered steel

upon the sides of a modern battle-ship, the step is, perhaps, no greater than between the reinforced cast-iron Lancaster rifle and the latest forged steel built-up Krupp, Canet or American gun. Nor has the contest at any time been greatly unequal. The dead and the disabled on both sides are to be found about the yards and upon the scrap heaps of every ordnance proving ground of both continents. To-day the gun is unquestionably in the lead, and when we have the announcement that an initial velocity of 2,550 foot-seconds has been obtained from a 9.45-in. Schneider all-steel rifle, using smokeless powder, with perfectly safe powder pressures, we find it hard to conceive that any known metal or combination of metals, of practicable thickness, can successfully stand up before the enormous energy which such high velocities imply.

WEAR OF METALS AS INFLUENCED BY THEIR CHEMICAL AND PHYSICAL PROPERTIES.

By Dr. Charles B. Dudley.

(Paper read before the joint meeting of the Iron & Steel Institute and the American Institute of Mining Engineers.)

In October, 1878, and again in February, 1881, I had the honor to make public, through the medium of the American Institute of Mining Engineers, the results of an extended study of steel rails which had been in service, and which were taken for the purpose from the tracks of the Pennsylvania Railroad Company. These studies appeared in three papers. In the first of these papers the question of what kind of steel is least liable to fracture or disintegration in the track was the principal one considered. In the second paper the question discussed was, Does the power of steel to resist wear increase with the hardness? In the third paper the relation between wear and the chemical and physical properties of the metal was the principal point considered. The general results arrived at, or the conclusions reached, were as follows: 1, that a mild steel is less liable to fracture, and, if properly made, less liable to crushing or disintegration in the track than a harder steel; 2, that the wearing power of steel in rails not only does not increase as hardness increases, but, on the contrary, diminishes; or, in other words, that a mild steel gives less loss of metal under the same service than a hard steel.

My own criticism of this work, after the lapse of 10 years, and after all the discussion which followed the publication of the papers above mentioned, may, perhaps, be fairly summed up in four conclusions:

1. If I had the work to do again I would certainly determine the sulphur in the rails, since all our studies during the past 10 years on the influence of sulphur point strongly in the direction of indicating that the sulphur has an important influence on steel, especially in its effect on the carbon.

2. The influence of silicon, and especially its influence from the metallurgical standpoint, seems to be much better understood now than at the time when these studies were begun, and if an ideal formula, representing our views as to the best possible composition for steel rails, was to be made at the present time, the silicon limit would be raised somewhat, possibly to the favorite figure of Mr. Sandberg—namely, 0.10 per cent.

3. It is possible that in the first paper published the influence of the chemical composition on what is commonly known as crushing or disintegration of rails in the track was made more prominent than the facts would warrant. More mature or riper studies would seem to indicate that disintegration or crushing of steel is hardly a resultant of lack of soundness in the ingot, and is more mechanical than chemical, except in so far as chemistry may be responsible for the soundness of the ingot. However, upon this point of sound ingots, we have seen little reason to modify the views held for some time, that time is more important in securing sound ingots, especially time in certain critical parts of the process than any other single element. If our views are correct, sound ingots, with consequently sound rails, can be made from steel of varying composition, provided time is allowed at the right points in the process, and the claim that high manganese and high carbon are essential to secure sound ingots is, in our judgment, not well founded, provided that time enough is allowed to make the steel properly.

4. In all our later studies on the wear of metal we have, as far as possible, avoided a method of deciding which metal is best which attempts to give what may be called absolute results. In other words, loss of metal by wear, per million tons, has some necessary errors in it, and, accordingly, in our later studies we have adopted this method of comparison: Two metals of different composition are subjected as nearly as possible to the same wear, and the one which wears the faster, by comparison with the other, is regarded as the poorer, as will be explained a little later. It would, perhaps, have been difficult to use this method on rails selected from different portions of the track, the extremes being somewhere about 100 miles apart, but if we had the work to do again a strenuous effort would be made to use the method of comparison. Of course, this is possible where direct positive experiments are made.

One point further in regard to the work already done on this subject. Samples of all the rails which were discussed in the third paper, above mentioned, have been carefully preserved with the idea in mind of some time repeating the work, with the improved means and methods which time and study in the realm of chemical metallurgy should place in our hands. Especially has it been hoped that some methods of chemical analysis would be devised which would enable us to determine, not only the total amount of carbon, phosphorus, silicon, manganese, sulphur, etc., in these various steels, but also how these substances were combined. For example, does the phosphorus in any given rail exist as phosphide, or partly as phosphate, or both? Is the silicon simply alloyed, or chemically combined with the iron? Does the carbon all appear as strength carbon, or is some of it graphitic, or combined with the iron in such a way as to form a crystalline body which adds nothing to the strength? The 10 past years have done something in unraveling these mysteries, but hardly enough, we think, has been developed as yet to enable us wisely to re-examine these rails. It has been our belief for some time that no decided step forward in the chemical metallurgy of steel could be taken until we have solved some of the questions as to how the various impurities which occur in steel exist in the metal, and we may add that it is not from lack of interest in the subject, but from necessary devotion to study in other lines, that our own work in this field, and our possible contributions to knowledge on this subject, have been so small.

Otherwise than as regards the criticisms above mentioned—namely, that the sulphur should have been determined, possibly the silicon limit raised a little, the influence of the method of manufacture on the final product made a little more prominent, and the comparative method used as far as possible in determining the difference between good and poor rails—we have seen little occasion to modify the conclusions stated in the papers as published—namely, that mild steel is not only safer for rails and for other constructive purposes, but also that mild steel gives better wear, or loses less metal under the same traffic, than harder steel. It seems quite probable that this conclusion will hardly be accepted by the mass of engineers, or by those who are engaged in metallurgical industry, and the object of this paper is simply to bring up to date the additional information which has been accumulated on this subject during the past 10 years. Meanwhile, what light has the past 10 years thrown on the special subject of the relation between wear and the chemical and physical properties of metal?

1. Since the papers above referred to were published no systematic study of steel rails has been attempted in the Pennsylvania Railroad Laboratory.

2. It will be remembered by those who are familiar with the discussion which followed the publication of the papers on steel rails, that some trial rails, according to the formula suggested in the first paper, were made in Germany, and inspected by Mr. Sandberg, who made his work the subject of a contribution to the discussion. The place where these rails went into service never came to my knowledge until a little over a year ago. At that time I

received a letter from Mr. P. H. Conradson, the Chemist of the New York & New England Railroad, stating that he had found in the records of that road that 2,500 tons of steel rails, in accordance with the formula suggested in the first steel-rail paper above referred to, had been made at Gütehoffnungshütte, Germany, and had been laid on their road. Mr. Conradson's letter gave the formula on which the rails were ordered, which is practically the formula of my first steel-rail paper, and also states that the records show a number of reports of inspection, signed by Mr. Sandberg, with analyses made by Mr. Magnus Troilius. A number of analyses are also given, taken from the tests of inspection, showing, in general, that the rails came within the limits of the specifications—namely, in no case was carbon above 0.35 or below 0.25 per cent.; manganese was in no case above 0.40 or below 0.30 per cent.; phosphorus was between 0.055 and 0.075 per cent., and silicon varied from 0.01 to 0.08 per cent.; most of them being about 0.05 per cent. The physical tests were also fairly close to the assigned limits of the specifications—namely, they were generally within 75,000 lbs. tensile strength per square inch, with not less than 20 per cent. elongation, the limits being from 73,000 to about 80,000 lbs. tensile strength per square inch, and 17 to 23 per cent. elongation. The rails weighed 60 lbs. per yard, and were put in the track where they could be subjected to the severest service. They remained at this point seven years, and were taken up to be replaced with a heavier rail. Upon receipt of Mr. Conradson's letter, the matter was brought forward with the officers of the road, with the idea in mind of obtaining positive figures as to the tonnage which had passed over the rails during the seven years, but although data on this point was promised, yet, owing to changes in the management, it was never furnished. We are, therefore, without positive data, expressed in figures, as to how these rails wore. The statements, however, of those most familiar with the rails while they were performing their service were to the effect that they were in every sense satisfactory, and that they gave excellent results. The words of the one most competent to judge, quoted by Mr. Conradson, are as follows: "These rails have not changed any during these seven years of continuous use so that it can be detected by the naked eye." It would be gratifying to have positive figures as to the tonnage and loss of metal by wear, but in the absence of this data it is perhaps not too much to say that even if we do not have from it so positive a confirmation of our views as could be desired, there is certainly nothing in the data to controvert the idea that mild steel gives better wear in rails than hard steel.

3. I am aware of the conclusions reached by M. Verschovsky, Engineer-in-Chief of the Russian State Railroads, which were stated in a paper read before the Railroad Congress in Paris in 1889. Those who have read this paper know that the conclusions reached by M. Verschovsky seem to be directly opposite to the conclusions which we have reached—namely (if we can trust the translation which I have), "the best wearing rails have the greatest tensile strength with the least elongation;" and again, that the "rails which broke were softer, as far as indicated by tensile strength and elongation, and there is a difference between a hard rail and a brittle one." Still further, as regards the chemical composition, "the best rails contain more carbon and manganese than the brittle ones, and in all cases much more silicon and less phosphorus." In the absence of data as to what constituted the best rails—that is, as to how the best rails were decided on—and in the absence of any positive data of loss of metal by wear, it is, of course, exceedingly difficult to criticise or explain the conclusions obtained by M. Verschovsky. However, one point in the paper seems to throw some light on the possibilities of the case. It is stated that, in consequence of the specifications issued by the Government, the steel works did all in their power to produce a soft steel, so as to insure that the "frozen rails should stand the falling or drop test prescribed," and that this result was accomplished, but that, as a concomitant of this soft steel, a new difficulty appeared, which was that after a few months of wear the rails began to crush or flatten at the ends, so that in a short time replacement was found necessary. To our minds this seems to indicate that as the result of the effort of the steel works to produce soft steel, very unsound or porous ingots were obtained, which produced rails that were not sound and homogeneous, and which would be likely to behave exactly as M. Verschovsky describes. It will be remembered that this difficulty of getting sound ingots with soft steel was largely the burden of the discussion which followed the publication of the steel-rail papers, and it seems fairly probable that the difficulty which M. Verschovsky describes may be entirely due to this cause. If the steel works, in trying to make the soft steel, so hurried the process that unsound and porous ingots were obtained, we see no difficulty in accounting for the conclusions which M. Verschovsky has reached.

4. Several years ago our attention was directed to the question of tires on locomotive driving wheels, which, as is well known, are made of steel. The question under discussion was the possibility of preparing specifications for locomotive ties, and, as a preliminary study, examination was made of a number of steel tires which had been in service. It may be stated here that for a number of years past the practical men in charge of the lathe shops on different portions of the Pennsylvania Railroad where tires are turned off noticed, and have stated in conversation, that they always had to turn off the most metal from the softest tire; that is to say, when the tires come into the shop for re-turning the very hard tires were the ones which had worn the most, the hardness being determined by the behavior of the tool during turning. This, of course, was simply an observation, and very little positive data could be drawn from it. A number of tires were taped as they came in from service to be re-turned, and in a short time three pairs of tires were found which showed marked differences in circumference. The circumference was measured by putting a tape around the tire. In one case the difference in circumference was 2 in., and in each of the other cases the difference was 1¾ in. This difference in circumference corresponds to a difference in diameter of from 0.55 to 0.63 in., or from 0.27 to 0.31 in. in the thickness of the tire itself. In other words, by actual measurement of tires which had been in service on opposite ends of the same axle, which were of the same diameter and circumference when they went into service, in the case of two of the pairs, one of the two tires had lost a little over ¼ in. of its thickness more than the other, while in the other pairs one had lost nearly ⅓ in. more of its thickness than the other. In view of this discrepancy in wear under as nearly as possible the same conditions, it was with a good deal of interest that analyses were made of the metal taken from these tires. The results of the analyses are as follows:

ANALYSES OF UNEQUALLY WORN TIRES, FROM OPPOSITE ENDS OF THE SAME AXLES, ON THE PENNSYLVANIA RAILROAD LOCOMOTIVES.

	Least worn tire.	Most worn tire.
ENGINE 654.	Per cent.	Per cent.
Carbon	0.594	0.708
Manganese	1.076	0.938
Phosphorus	0.039	0.101
Silicon	0.245	0.143
	Least worn tire.	Most worn tire.
ENGINE 136.	Per cent.	Per cent.
Carbon	0.541	0.625
Manganese	0.880	0.974
Phosphorus	0.062	0.063
Silicon	0.253	0.153
	Least worn tire.	Most worn tire.
ENGINE 626.	Per cent.	Per cent.
Carbon	0.525	0.554
Manganese	0.512	0.714
Phosphorus	0.032	0.037
Silicon	0.179	0.208

The tires of Engine 654 had a difference in circumference of 2 in.; the other two had a difference in circumference of 1¾ in. It is interesting to observe that in every case the carbon is lowest in the least worn tire, indicating the softest steel, so far as carbon is concerned. Again, in two of the three the manganese is lowest in the least worn tire. In one of the three there is quite a difference in phosphorus, the lowest being characteristic of the least

worn tire, the other two having very slight differences in phosphorus. In two the silicon is highest in the least worn tire, while in the other the difference is the other way. Of course it is impossible to draw any very general conclusions from so small a number of samples as three, but the teaching of these results would seem to be that, in general, lower carbon and manganese and higher silicon are characteristic of tires which give the best wear. It is fair to say, in this connection, that it is not at all impossible that the temper of this steel may have an influence on the wear, apart from the chemical composition. It is well known that tires are "set," as it is called—that is, are fastened upon the wheel center—by having the tire turned out to a diameter a little less than that of the wheel center, and then heating the tire to expand it, so that it will take the wheel center, and then cooling the tire. If, now, the tires are not heated to uniform temperatures, and cooled uniformly, or if they differ somewhat in their carbon, it is probable that one tire would have a different "temper" or "hardness produced by cooling" than another, and this might have an influence on the rate of wear. Of course no positive data can be given on this point at the present moment. Before leaving the wear of tires, permit me one word further. Confining ourselves to the question of wear, it is difficult to conceive of anything which produces wear in rails different from that which produces wear in tires, since, if we understand rightly, it is a strain between the wheel and the rail which causes the rupture or tearing off of the small particles which we are accustomd to call "wear." It would seem, therefore, that tires afford an admirable opportunity for studying the question of relative wearing power of hard and soft steel, and the experiments alluded to already are the experiments on the wear of tires. It seems probable that within six months, or possibly a year, we may have considerably more light on the relative wearing power of hard and soft steel than we now have.

5. Our studies on wear have not been wholly confined to the behavior of iron and steel under abrasion or rolling friction. A very large number of experiments have been made on the Pennsylvania Railroad with various alloys used as bearing metals. If these may be trusted, and our deductions are correct, those alloys which are least brittle give the best wear—that is, lose less metal under the same conditions than harder or more brittle alloys. Or, looked at in the light of definite physical properties, those alloys which give the slower wear are characterized by lower tensile strength and greater elongation than is characteristic of those giving more rapid wear.

The alloys experimented with have been principally the old copper-tin alloy—seven parts copper to one of tin—and alloys of copper, tin, and lead, with and without phosphorus and arsenic. The method has been to have a certain number of bearings made of a standard bearing metal—described later on—and the same number of the experimental metal. These bearings were placed on opposite ends of the same axles, either on locomotive tenders or cars, the axles so arranged that one-half of the experimental bearings were on one side of the car and one-half on the other side. The bearings were all carefully weighed before going into service, and after a sufficient lapse of time were taken out and reweighed. At first an attempt was made to give the loss of metal by referring it to the mileage, but the method of comparison was ultimately adopted, as giving results free from any possible difficulties introduced by mileage, so that all the results which we obtained are strictly comparative.

The standard bearing metal is what is known in this market as phosphor-bronze bearing metal, technically described by the Phosphor-Bronze Smelting Company as the "S. Bearing Metal." This metal contains approximately 79.70 per cent. of copper, 10.00 per cent. of tin, 9.50 per cent. of lead, and about 0.80 per cent. of phosphorus. It is, of course, a fair question, and one which has not been overlooked, whether the standard bearing metal gives uniform wear. A large number of experiments have been made on this point, the result being that the average wear of standard phosphor-bronze compared with the mileage, is best expressed by saying that the phosphor-bronze bearing metal loses 1 lb. of metal, worn off, for every 18,000 to 24,000 miles of travel. This, it will be observed, shows a discrepancy in the wear of the standard phosphor-bronze bearing metal, and the fact led us to abandon the method of making comparisons by mileage. The reasons for the discrepancy are not hard to find: First, the pressure per square inch in all tests were not the same, and consequently the wear would not be the same. On the other hand, with bearings on the opposite ends of the same axle, the pressures per square inch are approximately the same. Second, the state of the lubrication in different cars and engines, which is more or less characteristic of different parts of the road, is a very important variable, and undoubtedly goes far toward explaining the differences in mileage above given. This variation in the state of lubrication is not so apt to be characteristic of opposite ends of the same axle, as it is of different cars and locomotives. We are inclined to think, therefore, that the assumption that standard phosphor-bronze is sufficiently uniform in its behavior to warrant its being used as the basis of comparison will not lead us into serious error, at least if we confine ourselves to a direct comparison of the loss of metal obtained from standard bearings on one end of the axles and experimental bearings on the other end of the same axles. Usually 16 bearings of each kind were put in service as a preliminary experiment, and if the metal proved at all favorable on this preliminary trial, a larger trial, embracing 50 or 100 bearings of each kind, was put in service. The preliminary trials were usually made on locomotive tenders, where the bearings get the best possible care. The larger trials were more commonly made on cars. Of course, owing to the exigencies of the service, it sometimes happened that some of the bearings put in use were not returned to be weighed. This was more true where bearings became heated, and were removed at different points along the line, than at the regular inspection points. Whenever, from any cause, a bearing was missing, its opposite was not taken into account, so that in reality in the results given the comparisons are strictly between the same number of standard and experimental bearings on opposite ends of the same axles. Sometimes as high as one-half the bearings in an experimental lot would be lost. In other cases nine-tenths would be returned. The results of the tests, with the composition, and, so far as our knowledge goes, the physical properties of the various alloys tested, are given below. It is unfortunate that in the earlier tests the physical properties of the alloys were not taken. In the composition, approximately average analyses are given rather than a special analysis of the metal in each test, and it will be observed that there is no allowance made for the small impurities, such as zinc, antimony, iron, etc., which are usually characteristic of commercial metals used in making these alloys, especially where some scrap is used in making the bearings, as is almost always the case. It will also be observed that in all cases, in expressing the loss of metal by wear, the results are given in percentages of the metal lost by the standard phosphor-bronze.

COPPER-TIN VERSUS PHOSPHOR-BRONZE.

	Composition copper-tin. Per cent.	Composition phosphor bronze. Per cent.
Copper	87.50	79.70
Tin	12.50	10.00
Lead	None.	9.50
Phosphorus	None.	0.80

Wear.—First experiment, copper-tin wore 48 per cent. faster than phosphor-bronze; second experiment, copper-tin wore 53 per cent. faster than phosphor-bronze; third experiment, copper-tin wore 47 per cent. faster than phosphor-bronze.

ARSENIC BRONZE VERSUS PHOSPHOR-BRONZE—FIRST EXPERIMENT.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	89.20	79.70
Tin	10.00	10.00
Lead	None.	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 42 per cent. faster than phosphor-bronze.

ARSENIC BRONZE VERSUS PHOSPHOR-BRONZE—SECOND EXPERIMENT.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	89.20	79.70
Tin	10.00	10.00
Lead	7.00	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 15 per cent. faster than phosphor-bronze.

ARSENIC BRONZE VERSUS PHOSPHOR-BRONZE—THIRD EXPERIMENT.

	Composition arsenic bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	79.70	79.70
Tin	10.00	10 00
Lead	9.50	9.50
Phosphorus	None.	0.80
Arsenic	0.80	None.

Wear.—Arsenic bronze wore 1 per cent. faster than phosphor-bronze.

DAMASCUS BRONZE VERSUS PHOSPHOR-BRONZE.

	Composition Damascus bronze. Per cent.	Composition phosphor-bronze. Per cent.
Copper	77.00	79.70
Tin	10.50	10.00
Lead	12.50	9.50
Phosphorus	None.	0.80

Wear.—First experiment, Damascus bronze wore 8 per cent. slower than phosphor-bronze; second experiment, Damascus bronze wore 7.30 per cent. slower than phosphor-bronze.

	Composition Alloy "B." Per cent.	Composition phosphor-bronze. Per cent.
Copper	77.00	79.70
Tin	8.00	10.00
Lead	15.00	9.50
Phosphorus	None.	0.80

PHYSICAL PROPERTIES.

	Alloy "B."	Phosphor-bronze.
Tensile strength, per square inch, lbs.	24,000	30,000
Elongation, per cent.	11	6

Wear.—Experimental alloy "B" wore 13.50 per cent. slower than phosphor-bronze.

If we interpret the above results correctly, they indicate: 1, that copper-tin wears nearly 50 per cent. faster than standard phosphor-bronze; 2, that arsenic bronze, containing no lead, wears about 42 per cent. faster than phosphor-bronze; 3, that arsenic bronze containing 7 per cent. of lead wears less rapidly, the exact figure being 15 per cent. faster than phosphor-bronze; 4, that arsenic bronze containing the same amount of lead as phosphor-bronze wears but slightly faster, the figure being 1 per cent.; 5, that Damascus bronze containing as high as 12.50 per cent. of lead wears from 7 to 8 per cent. slower than phosphor-bronze; and, 6, that the experimental alloy "B," containing less tin and more lead than any of the other alloys experimented with (the figures being 8 per cent. of tin and 15 per cent. of lead, instead of 10 per cent. of tin and 9.50 per cent. of lead, as is characteristic of phosphor-bronze), wears 13.50 per cent. slower than phosphor-bronze. This last alloy is the only one of which we have the physical properties compared with phosphor-bronze, and it will be observed that it has considerably lower tensile strength with greater elongation than the phosphor-bronze. This characteristic of lower tensile strength and greater elongation, it will be remembered, is the same characteristic which has been so often alluded to in the case of steel—namely, the mild steel, which, as is well known, is characterized by lower tensile strength and greater elongation than harder steel, gives the best wear. Here, too, in the realm of alloys, that metal which gives the lower tensile strength and greater elongation, if our experiments can be trusted, gives the slower wear. As has already been stated, it is unfortunate that the physical tests of all the other experimental alloys were not taken; but there is another method of getting at the physical properties of these alloys which is instructive, and although not as definite, is, perhaps, almost as convincing as though the actual figures were given. It is well known that the alloy of two parts of copper to one of tin, which is commonly called speculum metal, is one of the most brittle substances known. If, now, the percentage is changed, and an alloy is made of three parts of copper to one of tin, it is less brittle than the first one. Four, five, six, seven, eight, etc., parts of copper to one of tin give alloys which are in every case less and less brittle, as the tin diminishes, if our data can be trusted. It is well known that the alloys of four, five and six and sometimes seven parts of copper to one of tin are used for making bells for various purposes. The alloy of seven parts of copper to one of tin is the copper-tin alloy used as bearing metal in our experiments. If this reasoning is correct, the law seems to be that the increase in copper and the diminution in tin, at least within the range of our experiments, give alloys which are less and less brittle in every case. In the experiments which we have made it will, of course, be urged that lead comes in as an important constituent in the alloy, and consequently the query arises, What influence has the lead on the alloy? The influence of the lead has not been worked out in figures to our knowledge, but so far as our observation and study have gone, the addition of lead practically amounts to the same thing as a still further diminution of tin; that is to say, an alloy containing any given percentage of copper and tin will be rendered more ductile and less brittle by the addition of lead to this alloy, which, if our reasoning is correct, is the result which follows a diminution of tin and an increase of copper. I have, in another place, tried to illustrate this subject at some length, and will not therefore, at this time, dwell longer upon it, except to say that in the only case in which we have a physical test of these alloys—namely, in the case of phosphor-bronze and the experimental alloy "B"—this law seems to be fairly well illustrated. In the standard phosphor-bronze, the ratio of copper and tin is very nearly 1 to 8, while in the experimental alloy "B" the ratio of copper and tin is about 1 to 9.6. The percentage of lead in phosphor-bronze is 9.50, and in the experimental alloy "B" 15 per cent. The marked influence of these changes on the tensile strength and elongation is very clear. The tensile strength is cut down 6,000 lbs. per square inch, or about one-fifth, and the elongation is increased to nearly double that of phosphor-bronze. I will add for information that the experimental alloy "B," with a slight modification so as to enable the foundry to use the large quantities of phosphor-bronze scrap which the Pennsylvania Railroad possesses, and which results in giving from 0.10 to 0.20 per cent. phosphorus in the finished bearing—the percentage of the other constituents being those given above—is now the standard bearing metal of the Pennsylvania Railroad, and no information has been obtained, during some six years of constantly increasing use of this metal, which would controvert the conclusion given above, that the experimental alloy "B" wears slower than standard phosphor-bronze. It is possibly hardly necessary to add that we are not able to draw from our experimental work in the realm of alloys any other conclusion than that those alloys which are least brittle, or, measured in technical language, which have lower tensile strength and greater elongation, give better wear as bearing metal than those alloys in which the reverse is the case; or, in other words, that in the realm of the alloys, so far as our experiments have gone, the same thing holds true which we have therefore found in regard to steel—namely, the softer the metal the better wear it gives.

A few points further in regard to wear. We are not aware that any attempt has ever been made to formulate the variables on which wear depends; or, in other words, to enunciate a theory of wear, and it is entirely possible that the data in our hands, which are reliable enough to be so used, are not at all sufficient to warrant us in making such an attempt. Our observations, however, have led us to philosophize on this subject, and at the risk of

saying something which future experiments may very greatly modify, or possibly show to be fallacious, we will venture to state a few of the variables which enter into wear.

Of course, wear is influenced by the conditions under which it takes place, but it is not our purpose to discuss these variables which may fairly enough be called "concomitant conditions." We will therefore not discuss lubrication, pressure, speed, temperature, rolling friction, or abrasion, nor indeed the nature of the two metals rolling or sliding over each other, but will confine ourselves wholly to the qualities of metal, which, all other things being equal, give least loss of substance by wear under the same service. To our minds we are justified in assuming that at least three elements enter into the problem of wear:

1. That metal which will suffer the most distortion without rupture will wear best. This quality of metal is usually measured or expressed in figures by the well-known physical data "elongation" or stretch before rupture in the common physical test. Possibly the experimental data on this point are greater than we possess on any other of the variables which enter into wear. If we may trust the data which we have brought forward, and the conclusions drawn from them, in all cases the greatest elongation is characterized by the best wear; or, according to the law, that metal which is characterized by the greatest power to resist distortion without rupture will wear best.

2. The first variable being obtained in satisfactory amount an increase in tensile strength will add to the wearing power of the metal. The diminution of tensile strength, which is characterized by the better wearing metals, according to our data, is not, if we are correct, a desirable quality. It is a concomitant of most metal that as it increases in its power of elongation, or stretch, before rupture, it diminishes in tensile strength. If, on the other hand, a new metal could be found, which, with any given elongation, was characterized by a higher tensile strength than some old and well-known metal with the same elongation, the new metal would, if the theory is correct, wear better than the old one. It is not difficult to say why an increase in tensile strength should be valuable in assisting wear, provided the power of distortion before rupture is not interfered with. Wear, as we understand it, is the tearing off of minute particles, and if in one case it requires more force to tear off the particles than in another, the wear in that case will be slower. We have, we think, a little experimental data which points in this direction. The wear of bearings per thousand miles is about three times as fast as the wear of axles; in other words, as has already been stated, the standard phosphor-bronze bearing metal loses about a pound for each 25,000 miles that the bearing moves. The axle under it loses about a pound for each 75,000 miles, but the metal of the axle is from two to three times as strong per square inch, and its elongation is also somewhat higher than the bearing metal alloy.

3. The third variable which enters into wear, as we look at it, is what may perhaps be termed the "granular structure of the metal." This may, perhaps, best be illustrated by saying that, of two metals which have the same tensile strength and the same elongation, the one which is finer in granular structure will wear the slower. This we think will be evident by returning to our conception of what wear is—namely, the tearing off of minute particles from the worn body. If, now, at each rupture of a particle of metal, the particle torn off is in one case twice as large as in the other, the wear will be twice as rapid, and we assume that, other things being equal, the granular structure represents the size or fineness of the particles torn off at each operation during wear. We have but little experimental data on this point. It is generally believed by those who have a chance to make observation that what is known as case-hardened iron wears better than either the wrought iron from which it is made or than ordinary hammered steel of approximately the same carbon. It has also been observed that case-hardened metal is always characterized by an extremely fine granular structure, as evidenced by the fracture. This, of course, is only an observation, and cannot be taken as proving very much. It is also entirely possible that the influence of what is technically known as "tempering," on wear, may appear in the effect of the temper on the granular structure. The field is, of course, too void of experiment and too little known to warrant anything more than suggestions.

The relation and interaction, so to speak, of the three variables mentioned above is, of course, quite an unknown field. We are inclined to think that the experimental data which have been obtained point clearly to the conclusion that the increase in tensile strength at the expense of elongation is disastrous, as far as wear is concerned. An increase in tensile strength with an increase in elongation would unquestionably, we think, be valuable. The influence of the structure or granular condition may be even more important than either elongation or tensile strength. Of course the data do not warrant any conclusions, but it seems not at all improbable that the size of the particle torn off, each time one is torn off, may be the most important variable in the rate of wear. It is also not improbable that if some method of measuring the granular structure of metal, and rightly estimating its influence on wear, was known, this information would go far toward explaining many of the anomalous cases of wear, which, if our experience is worth anything, are almost universal accompaniments of experiments in this field.

The whole subject of the relation between wear and the chemical and physical properties of metal needs study and positive experiment, and it is quite possible that much that we are accustomed to rely on at the present moment may be upset or overthrown by wider knowledge. The best we can say at present is that, with the light which we have, the highest tensile strength, accompanied by the highest elongation and the finest granular structure, are the physical properties which will probably give the best results in actual service where the metal is subjected to wear, and that that chemistry which will give these results in the finished product, be it in the realm of the alloys, or in the magnificent field of steel metallurgy, or, possibly, in the coming field of a metallurgy based on aluminum, is the best chemistry which we, at the present moment, are able to recommend.

Foreign Naval Notes.

The accompanying table, compiled from figures recently published in London, gives the number of war ships of modern type owned or under construction by the principal nations of Europe. Only those are included which have been built since the construction of armored vessels began. The first-class ships include the heavy battle-ships, fighting cruisers, rams and

Country.	First-Class Ships.				Cruisers.			Torpedo Vessels.		
	Battle-ships.	Armored Cruisers.	Coast Defense.	Total.	Protected.	Unprotected.	Total.	Torpedo Cruisers.	Torpedo Boats.	Total.
England:										
Built up to 1890.	47	12	11	70	44	38	82	46	86	132
Now building.	10	....	....	10	41	....	41	....	....	....
France:										
Built up to 1890.	19	9	21	49	11	41	52	39	78	117
Now building.	4	5	5	14	5	....	5	...	...	....
Germany:										
Built up to 1890	7	5	15	27	2	20	22	24	94	118
Now building.	4	....	9	13	8	2	10	....	....	....
Austria:										
Built up to 1890.	11	....	....	11	1	9	10	12	23	35
Now building.	....	...	...	...	2	1	3	....	....	....
Italy:										
Built up to 1890.	19	....	...	19	8	12	20	22	61	83
Now building.	5	..	....	5	7	....	7	....	....	....
Russia:										
Built up to 1890.	12	6	18	36	3	26	29	15	50	65
Now building.	3	2	1	6	2	4	6	....	...	....

floating batteries; the cruisers those over 1,000 tons built especially for cruising service; the third-class those built for torpedo service only.

It will be seen from this table that protected cruisers apparently meet with most favor, as there are few of the unprotected class now under construction; only 7 altogether, against 65 of the protected type.

It is stated that the total number of vessels of all classes which will be owned by the different nations in 1895—making no allowance for additions not yet proposed, or for losses which may occur in the mean time—will be as follows:

Nation.	Modern Types.	Older Types.	Total.
England	335	67	402
France	237	62	299
Germany	190	62	252
Austria	59	30	89
Italy	134	81	215
Russia	142	55	197

One item in the above tables may be changed very much before 1895, however; the future of the torpedo-boat must be considered very uncertain, as matters stand at present, and if results more favorable than are now expected should be obtained, their numbers may be considerably increased before 1895, since these vessels are generally small, and can be built in a comparatively short time. A battle-ship or heavy armored cruiser takes usually two or three years for its completion, and it is not probable that by 1895 there will be many more than indicated by the first table.

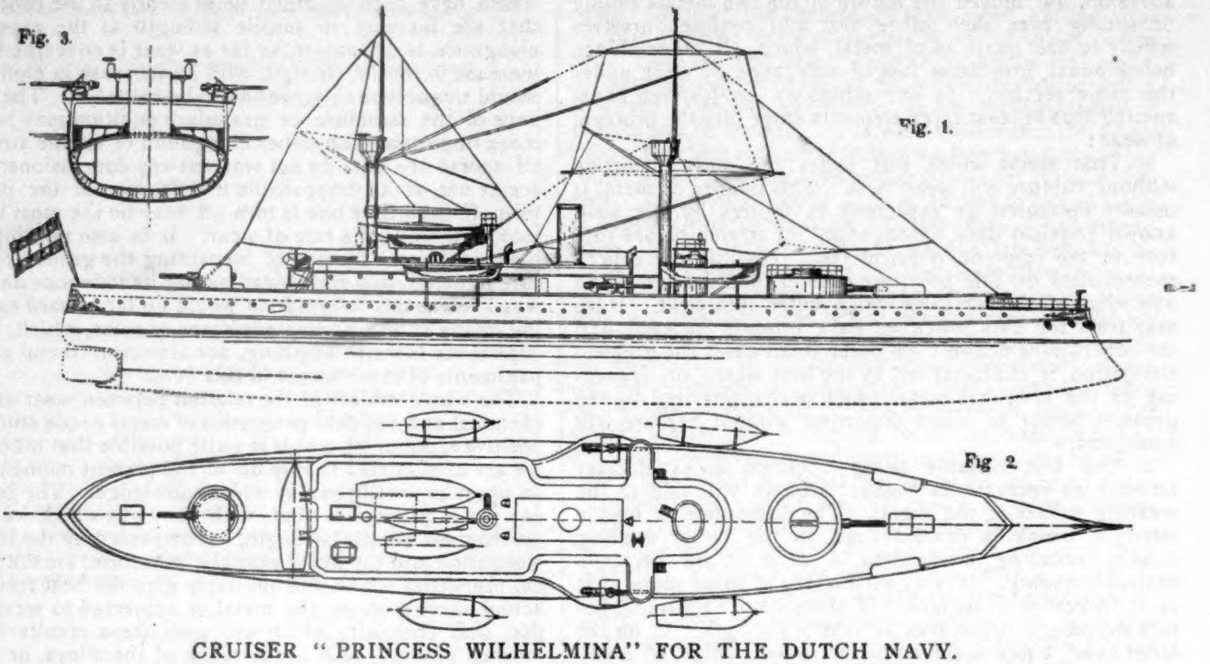
Quite a number of the English battle-ships were built before 1881, and are of types now considered out of date; some of the larger ones of earlier dates are bad ships to handle, slow and of doubtful efficiency in a seaway.

THE FASTEST CRUISER.

The first-class protected cruiser *Blenheim*, recently launched, is expected to be the fastest vessel of large size in the English Navy, her trial speed being fixed at 22 knots an hour.

The *Blenheim* is 375 ft. long, 65 ft. broad amidships and 38 ft. deep; her displacement is 9,000 tons on a mean draft of 25 ft. 6 in. Her engines, of the triple-expansion type, are expected to work up to 20,000 H. P.

The armor, weighing some 1,190 tons, is principally concentrated upon the protective deck. The hull is constructed of steel upon the usual cellular system. The hold-space is subdivided minutely by water-tight bulkheads and decks, and there is a cellular double bottom. The inner protective deck, which has for those looking into the interior from above the appearance of a second vessel encased in that which is visible from without, consists of a roof of curved steel covering the hold from stem to stern, the eaves of the roof, so to speak, being 6½ ft. below, while the top rises 1½ ft. above the water-line. This sharply curving deck is 6 in. thick over the machinery and engines, and 3 in. thick elsewhere. The vitals of the ship—the propelling apparatus, steering gear, magazine and shell-rooms—will all be beneath its protection. Tnere is no vertical side armor.



CRUISER "PRINCESS WILHELMINA" FOR THE DUTCH NAVY.

The armament will consist of two 24-ton guns mounted one forward and one aft; ten 5-ton guns, six mounted on the upper deck and four on the maindeck; sixteen 3-pdr. rapid-fire guns; one 1 in. and seven 0.45-in. Nordenfelt machine guns; four 14-in. Whitehead torpedo tubes.

The *Blenheim* was designed by Naval Constructor White; the hull has been built by the Thames Iron Works & Shipbuilding Company, and the engines by Humphrys, Tennant & Company. The trial speed of 22 knots is expected to give her an average sea speed of 18½ knots in fair weather.

THE LATEST DUTCH CRUISER.

The accompanying illustration shows the protected cruiser *Princess Wilhelmina*, lately completed for the Dutch Navy. In this cut, which is taken from the *Mittheilungen aus dem Gebiete des Seewesens*, fig. 1 is a side elevation; fig. 2, a deck plan, and fig. 3, a cross-section of the ship.

The general dimensions of this vessel are: Length, 328 ft.; greatest breadth, 48.9 ft.; depth, 29.3 ft.; mean draft, 19.7 ft.; displacement, 4,600 tons.

The ship is sheathed with pitch-pine planking and copper sheathing to a point 4.26 ft. above the water-line at ordinary displacement. As will be seen from the drawing, she carries a center redoubt with armor 5 in. in thickness, and is further provided with an arched armored deck, which is also 5 in. in thickness outside of the redoubt. Above the armored deck the sides are protected with coffer-dams 30 in. in width, filled with cellulose. The turret on the forward deck has 11 in. of armor backed by 8.66 in. of teak, while the after turret or shield is also heavily armored and the pilot house at the forward end of the redoubt has 11-in. armor.

The main battery consists of one 11-in. breech-loading rifle in the forward turret; one 8.3-in. breech-loading rifle in the after end and two 5.7-in. guns carried in sponsons amidships and mounted on pivots, so as to give each a range of 180°. The secondary battery consists of six machine guns and eight rapid-fire cannon, two of the former being carried in the military tops on the two masts. There are also three torpedo tubes, two mounted amidships and one forward.

There are four engines, two on each propeller shaft. These engines are all of the vertical triple-expansion type, having cylinders 19 in., 31 in. and 51 in. in diameter and 27 in. stroke. Steam is furnished by four cylindrical boilers 14 ft. in diameter and 11 ft. long, built to carry a working pressure of 170 lbs.

An auxiliary boiler is provided to run the pumps and other auxiliary machinery.

The ship is provided with a full outfit for electric lighting, including search-lights, and there are two dynamos of equal size, so that the lights will not be cut off by injury to either one.

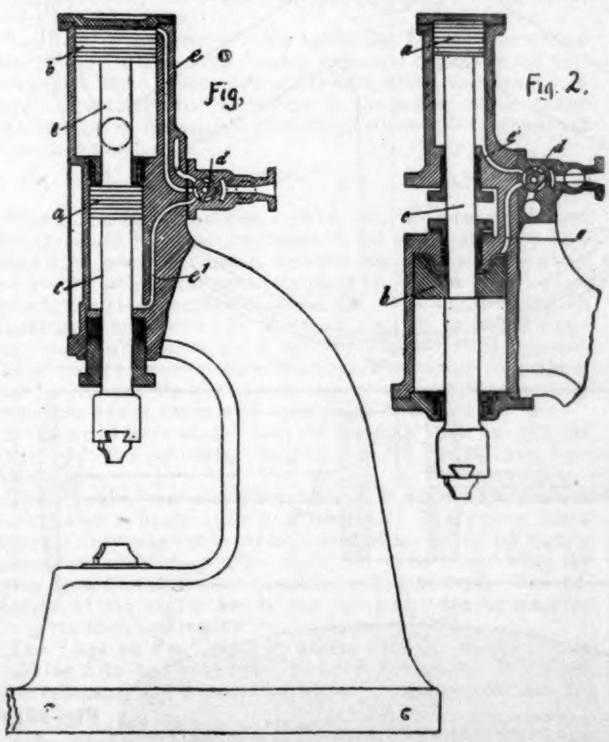
The ship has a double bottom, is divided into numerous water-tight compartments in the usual manner, and the coal bunkers are so arranged as to afford further protection. The normal coal capacity is 450 tons. The speed provided for is 16¼ knots per hour with forced draft. At full speed the engines are expected to make 170 revolutions per minute, and to develop about 5 900 H. P. The crew will consist of 325 officers and men.

THE PORTUGUESE NAVY.

A recent decree providing for the reorganization of the Portuguese Navy has been made public. It will consist of 4 armored battle-ships for coast defense ; 10 protected cruisers from 3,500 to 4,500 tons displacement and a high speed ; 18 first-class gun-boats of 600 tons ; 12 second-class gun-boats, for colonial service, of from 150 to 300 tons ; 1 school-ship ; 24 torpedo-boats and 2 transport steamers of 3,500 tons. Two ships, the battle-ship *Vasca da Gama* and the transport *India*, are to be completed shortly, while the construction of the remaining three battle-ships, of six cruisers, 8 gun-boats, 20 torpedo boats and the school ship is to be begun immediately. In addition to the two ships mentioned above three gun-boats of the second-class are already in service in African waters, while one of the first and one of the second class are under construction. The old style vessels now constituting part of the fleet will be retained for the present, as it is considered that they will be useful as foreign cruisers and in colonial service. The type adopted for the cruisers somewhat resembles that of the Italian *Piemonte* and the English *Blake*. Where the new ships will be built is not yet known ; it will hardly be in English yards, as there is a very bitter feeling against that country in Portugal at present.

A Compound Steam Hammer.

THE accompanying illustration shows a compound steam hammer recently patented in England by Julius E. Reinecker, of Chemnitz, Saxony. The hammer shown is of the double-acting type, the upward or lifting stroke being given by the high-



COMPOUND STEAM HAMMER.

pressure cylinder, and the downward stroke or working blow by the low-pressure cylinder. The inventor claims that in this way the full advantage of the expansion of the steam is obtained.

As shown in fig. 1, there are two cylinders, one above the other, with two pistons, *a* and *b*, having a piston-rod *c* common to both. The valve *d* is so operated that the steam passes first through the passage *e'* into the small or high-pressure cylinder below the piston *a*, thus raising the hammer ; the valve then establishes communication between the lower and upper cylinders, and steam passes from the high-pressure cylinder through the passages *e'* and *e* to the large cylinder above the piston *b*, where it aids the force of gravity, or weight of the moving parts, in giving the downward blow of the hammer.

The spaces in the cylinders above the small piston and below the large piston are in communication with the atmosphere, in order to prevent resistance to the motion of the hammer.

Fig. 2 shows a method by which this arrangement can be applied to old hammers. The existing cylinder is used as the high-pressure, and a low-pressure cylinder is attached to the frame below, in any convenient manner. In this case, as will be seen, the position of the cylinders is simply reversed, the action being substantially the same.

This arrangement presents some advantages, but it seems as if the gain, in so simple an engine as the steam hammer, was hardly sufficient to compensate for the cost of the additional parts and the greater complexity of the structure.

Electric Railroads in Cities.

(From the *Electrical Engineer*.)

SOME very interesting information has just been issued by the Census Bureau, in a bulletin of which Professor H. C. Adams is the author, giving statistics as to the rapid transit facilities in this country in cities of over 50,000 inhabitants. There are about 50 such cities. We append two tables containing the data :

Year.	Total mileage.	Increase. Miles.	Per cent.
1880	2,689.54		
1881	1,765.95	76.41	4.52
1882	1,875.10	109.15	6.18
1883	1,941.49	66.39	3.54
1884	2,031.84	90.35	4.65
1885	2,149.66	117.82	5.80
1886	2,289.91	140.25	6.52
1887	2,597.16	307.25	13.42
1888	2,854.94	257.78	9.93
1889	3.150.93	295.99	10.37
Total		1,461.39	86.50

The per cent. of total mileage of 56 principal cities operated by various kinds of motive power was :

	Miles.	Per cent.
Animal power	2,351.10	74.62
Electricity	260.36	8.26
Cable	255.87	8.12
Steam (elevated roads)	61.79	1.96
Steam (surface roads)	221.81	7.04
Total	3,150.93	100.00

The length of line assigned to each of the five leading cities in 1889 was as follows : Philadelphia, 283.47 miles ; Boston, 200.86 ; Chicago, 184.78 ; New York, 177.10 ; Brooklyn, 164.44. The number of miles of track assigned to each city is as follows : New York, 368.62 ; Chicago, 365.50 ; Boston, 329.47 ; Brooklyn, 324.63 ; Philadelphia, 324.21.

The apparent preponderance of Brooklyn and Philadelphia is explained by the fact that in those cities the roads are often single track, going out on one street and returning by another. New York, for example, has 161 miles of double-track road and Philadelphia only 39.

But the main point of interest is the relation between electricity and the other motive powers. The figures above show that in 56 leading cities it is only 8 26 per cent.—a respectable figure, it is true, but still small. On the other hand, the figures for the whole country, as we had occasion to prove recently, are very different. They run thus :

Miles of horse railroad	5,902½
" " electric "	1,753
" " dummy "	556
Cable	441
Total mileage	8,652½
Number of electric roads	164
" " cable "	44

Here, it is seen, electricity is more than 25 per cent. already of the total mileage. It is also more than 25 per cent. of the total number of roads, there being nearly 1,000 in all, but only 807 in independent operation.

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

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(*Continued from page 473.*)

CHAPTER VI.—(*Continued.*)

BELT-PULLEYS.

Figs. 179–181 represent an ordinary belt-pulley used for the transmission of power to or from one shaft to another. The right hand half of fig. 180 is a section on the line *C O* of fig. 179, and the left hand half is a section through the spoke and on the line *D O*. This method is often adopted when it is desirable to show the form of an object at two different places. In the present instance the right-hand side of fig. 180 shows the shape of the rim and hub of the pulley, and the left-hand side shows the form and dimensions of one of the spokes. Fig. 181 is a full-sized transverse section of one of the spokes on the line *A B* of fig. 179. It is often desirable to draw a section of this kind full size when the other views are represented on a smaller scale. The learner is advised to draw the pulley either half or quarter size, and the section of the spoke full size.

At one time it was considered necessary to make the arms or spokes of pulleys of a curved form, so that they could "spring" or "give" if there was any unequal contraction when the casting was cooled. It has been found by experience that this is not essential if the casting is allowed to cool slowly, and now the spokes of such pulleys are nearly always made straight in this country.

As a great many belt-pulleys are used in transmitting and distributing power, it is important in designing them that they should have sufficient strength, and at the same time that no superfluous material should be put into them. This has led to a very careful study of their proportions, rules for which will be given.

In the first place, the rim of a pulley should be somewhat wider than the belt. No great exactness is required, however, in proportioning the rim to the belt; but if the former is made about *one-eighth wider than the belt* it will give good results.

The face of the pulley, on which the belt runs, should be made convex, excepting for shifting belts. The amount of convexity should be about ½ in. per foot of width of pulley face. This would make a pulley with a face 12 in. wide ½ in. larger in diameter in the middle of the face than at its edges. For pulleys with 4 in. faces or less, and those of small diameter, and for high speed, the convexity may be increased.

Unwin, in "The Elements of Machine Design," says the thickness of the rim at its edge should be *equal to three-quarters of the thickness of the belt* $+ \frac{5}{1000}$ *the diameter of the pulley.* The following is given as about the average thickness of single belts:

Width of belts, in. …	2	3	4	6	8	10	12	15
Thickness of belts, in.	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{13}{64}$	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{25}{64}$

The number of arms in a pulley is purely arbitrary, and is generally increased with the diameter. The easiest way to draw the arms is to describe a circle from the center *O* of the pulley, fig. 179 (represented by a dotted circle in this case). Then subdivide the rim into as many equal spaces as there are arms, and draw center lines *D O, E O* through the points of division *D E*, and the center *O* of the pulley. From the points of division describe arcs on each side of the center lines, as shown at *E* and *D*. Then draw lines tangent to the arcs and to the dotted circle at the center. These lines will represent the outlines of the spokes.

The following rule has been given by Unwin for calculating the diameters *W* and *w* of the circles at the hub and rim: *Multiply the width of the face and the diameter of the pulley together, and divide by the number of spokes. Take the cube root of the quotient and, for single belt pulleys, multiply it by* 0.6337; *for double belts multiply by* 0.798; *the product will be the diameter W of the circle at the center.* The diameter *w* at the rim should be ⅔ of *W*. The thickness of the arms should be ½ their width. This may be laid off at *a* and *b* fig. 180, *a* being equal to ½ *w* and *b* equal to ½ *W*.

A rib *r r* is cast on the inside of the rim between the spokes, to strengthen the rim. This rib is of the same thickness as the spokes, and its projection *c* from the rim is also equal to their thickness. The radii *d* and *e*, fig. 179 of the curves which join the spokes to the rim and to each other are entirely arbitrary, and may be left to the judgment and taste of the draftsman. After locating the center of one of each of these curves, arcs of circles should be drawn from the center *O* through each point, where a center must be located. This facilitates the finding of the exact position of the centers, which will be in the arcs thus drawn.

BELT PULLEY.

Scale 1½ in.=1 ft.

Fig. 179.

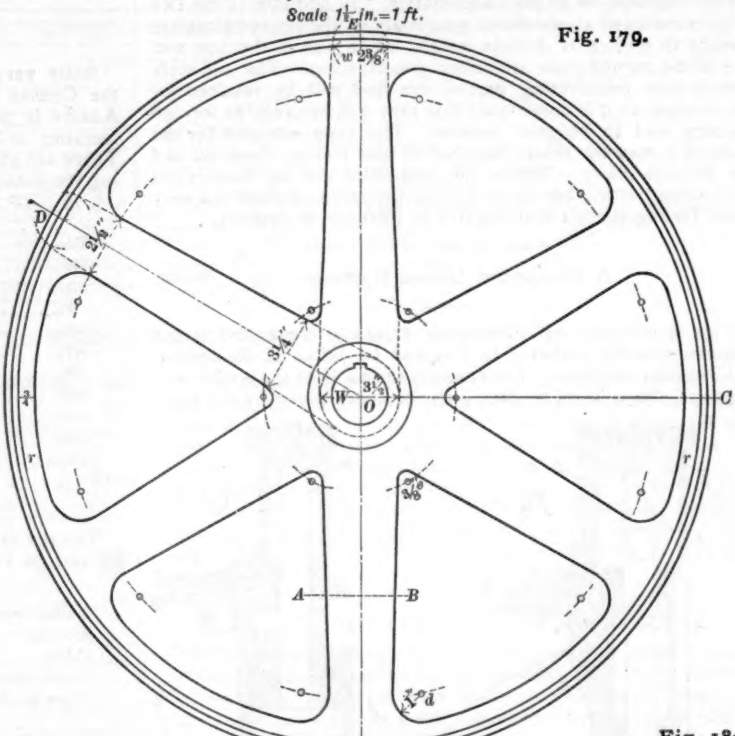
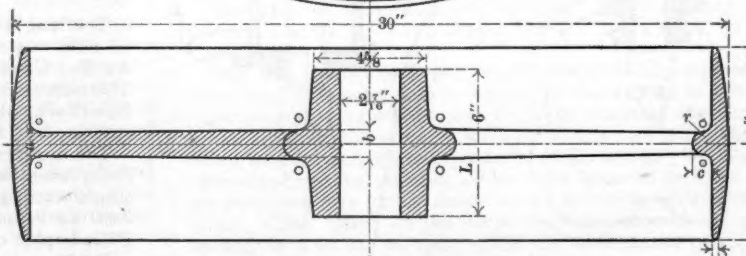


Fig. 180.



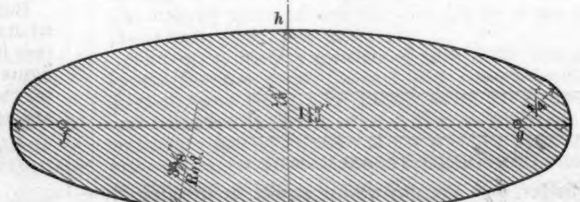


Fig. 181.

FULL SIZE SECTION OF SPOKE ON LINE A.B.

The length L of the hub, fig. 180, is usually made three-quarters the width of the face, and the thickness of the metal outside the shaft may be calculated as follows: *Multiply the diameter of the pulley by the width of its face in inches. One-sixth of the cube root of the product will be the thickness of the metal at the faces of the hub.*

Fig. 182.
SADDLE KEY.

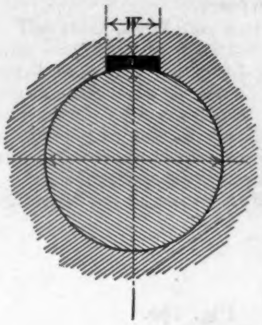


Fig. 183.
KEY ON FLAT.

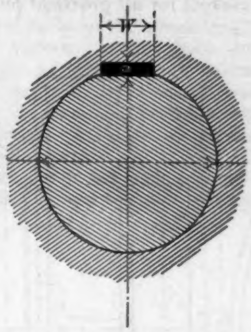
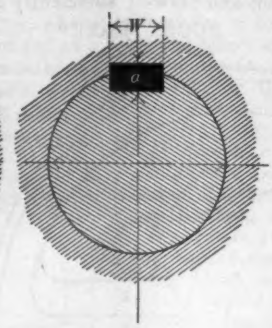
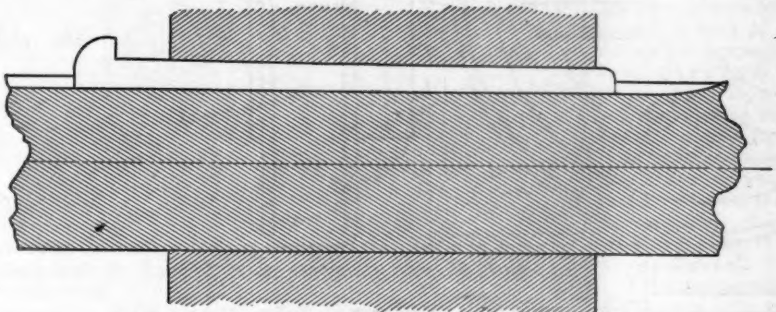


Fig. 184.
SUNK KEY.





SECTION OF SHAFT AND HUB SHOWING KEY.
Scale ½ in.=1 in.
Fig. 185.

The form of the section of the spoke, fig. 181, may be drawn with dividers from centers f and g, and other centers on the vertical center line h i, extended above and below the figure. A more elegant form for the outline of the section of the spoke is a true ellipse, the method of drawing which will be described in another chapter.

KEYS.*

Wheels, pulleys, couplings, cranks, etc., are prevented from turning round the shaft by means of flat wedge-shaped pieces called keys, which are driven between the shaft and the wheel in a groove or grooves cut in the shaft or hub, or both. Figs. 182–184 represent sections of shafts and of part of the hubs on the shaft. The groove d in the shaft, fig. 184, is called a *key-way*; those in the hubs, d d d, figs. 182–184, are called *key-seats*. The width W, figs. 182–184 of the keys is the same throughout their length, but their thickness tapers or decreases gradually toward the end at the rate of from about 1 in 24 to 1 in 96.

Keys are of three kinds—viz., the "saddle" key, fig. 182, the "key with flat on shaft," fig. 183, and the "sunk" key, figs. 184 and 185.

The "saddle" or hollow key, fig. 182, is made with its under face concave to fit the surface of the shaft. It is driven into a groove or key-way cut in the hub, and when driven up tightly causes the wheel to grip the shaft. It is only used when the power to be transmitted is small, as in belt pulleys. The advantage of the saddle key is that the pulley can be removed along the shaft and readily secured in any position.

The "key on flat," fig. 183, differs from the saddle key in requiring a flat bed to be made for it on the shaft. It is much more common, and a somewhat stronger arrangement than the saddle key.

The "sunk key," fig. 184, is the most trustworthy form, and is the one adopted for all purposes where the power to be transmitted is at all considerable. For this key a groove is cut in the shaft, in which the key is firmly embedded, the remainder of the key fitting into a corresponding recess in the hub, as shown in the figure.

The width W of keys is made = ¼ the diameter of the shaft + ⅛ in. The depth d in the middle of the saddle key and key on flat = ¼ the width. The depth d of the sunk key = ⅓ its width.

* The following description of keys is taken from Ripper's "Machine Drawing and Design."

Fig. 185 is a section of a shaft and hub showing a side view of a key. If the end E of the key is inaccessible to drive it out of the key-seat a gib-head G is put on the opposite end, so that the key can be removed by driving a wedge between its head and the hub.

Shafting is usually made of round bar iron of the regular sizes, which is reduced in diameter about $\frac{1}{16}$ in. by turning. For this reason standard sizes of shafting are of the following diameters: $1\frac{7}{16}$, $1\frac{11}{16}$, $1\frac{15}{16}$, $2\frac{3}{16}$, $2\frac{7}{16}$, $2\frac{11}{16}$, $2\frac{15}{16}$, $3\frac{3}{16}$, $3\frac{7}{16}$, $3\frac{11}{16}$, $3\frac{15}{16}$, $4\frac{3}{16}$, $4\frac{7}{16}$, $4\frac{15}{16}$, $5\frac{7}{16}$, $5\frac{15}{16}$, $6\frac{7}{16}$ and $6\frac{15}{16}$ in.

The student is advised to calculate the proportions and draw keys full size for shafts $1\frac{15}{16}$ and $4\frac{3}{16}$ in. diameter.

CHAPTER VII.

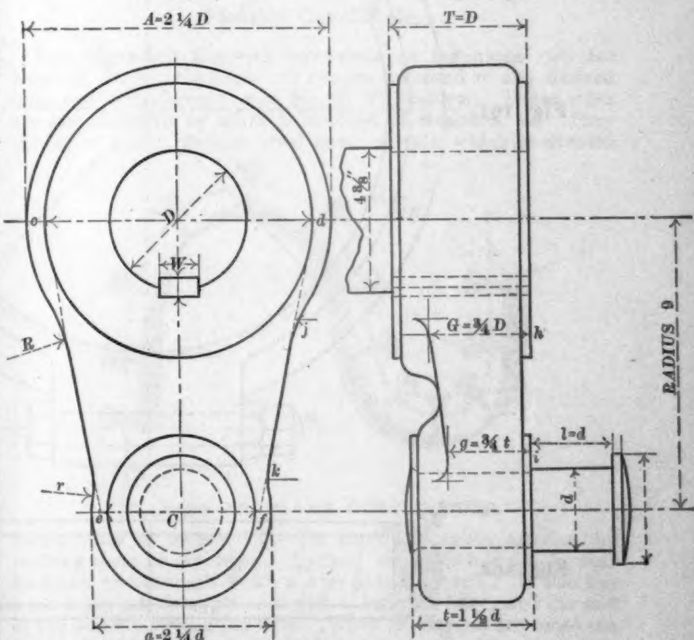
THE STEAM-ENGINE.

One of the principal organs of a steam-engine is the crank, as it is by means of it that the reciprocating motion of the piston is converted into the rotary motion of the shaft. In this country the cranks of stationary engines are generally made of cast iron. Figs. 186 and 187 are front and side views of such a crank for an engine* with a 10-in. cylinder and 18-in. stroke.

Such cranks should be proportioned to the diameter of the shaft, which is represented by D in the engravings. The *radius* of the crank is the distance from the center of the shaft D to the center C of the crank-pin, and is equal to half the stroke of the piston. The *throw* of the crank is equal to twice its radius, and to the stroke of the piston.

The thickness T of the boss on the shaft is equal to D, the diameter of the shaft. The diameter A of this boss is equal to 2¼ times D. No exact rule can be given for the diameters d of crank-pins, as practice varies within wide limits. The general

Fig. 186. Fig. 187.



CRANK.
Scale 2 in.=1 ft.

tendency with all classes of engines is to increase the diameters of the pins. In the present instance, d of the pin C is 2¼ in. diameter, and its journal is the same length. *The diameter a of*

* This and the following illustrations in this chapter are taken from drawings of a stationary engine built by the Fishkill Landing Machine Company at Fishkill on Hudson, N.Y.

crank-pin boss is made 2½ times d that of the crank-pin, and the thickness t of the boss is 1½ d.

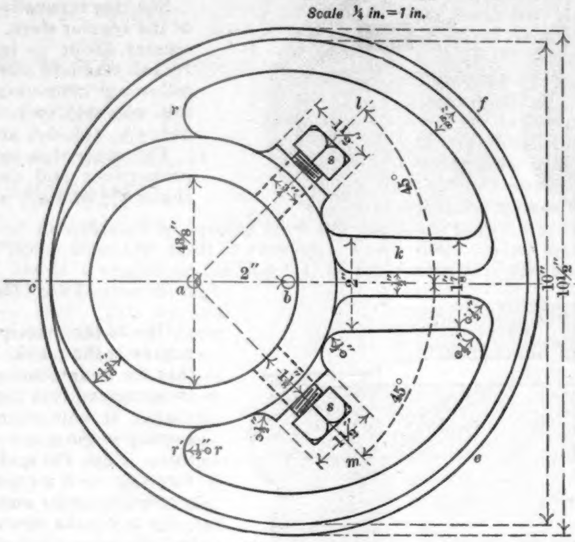
The outline of the crank-arm may be drawn by laying off from the center of the shaft on a horizontal center line passing through it a distance *c d* equal to twice the diameter of the shaft, and from the center of the crank-pin laying off a similar distance, *e f* = to twice the diameter of the crank-pin, and drawing lines *c e* and *d f* through the points thus laid down. Curves should be drawn, with radii *R* and *r* equal to the radii of the two bosses, tangent to the outlines of the bosses and the lines *c e* and *d f*.

The thickness G of the crank-arm where it joins the large boss is equal to ¾ D, and the thickness g is equal to ¾ t. To draw the outline *G g*, lay off the thickness from *h* and *i*, and draw vertical lines, as shown at *G* and *g*. Then with the T-square draw horizontal lines from *j* and *k* of fig. 186, extended to *G* and *g*. With a radius somewhat greater than that of the curve which joins the crank-arm to the hubs, draw curves at *G* and *g* tangent to the horizontal and vertical lines. These will represent approximately the outline of the back side of the crank-arm, and is sufficiently correct for all practical purposes.

ECCENTRIC.

Scale ⅛ in. = 1 in.

Fig. 189.



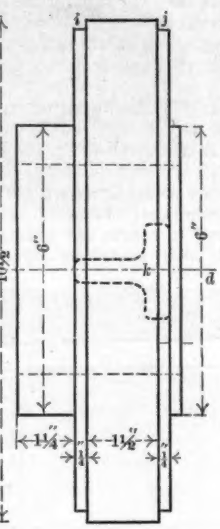


Fig. 190.

Fig. 191.

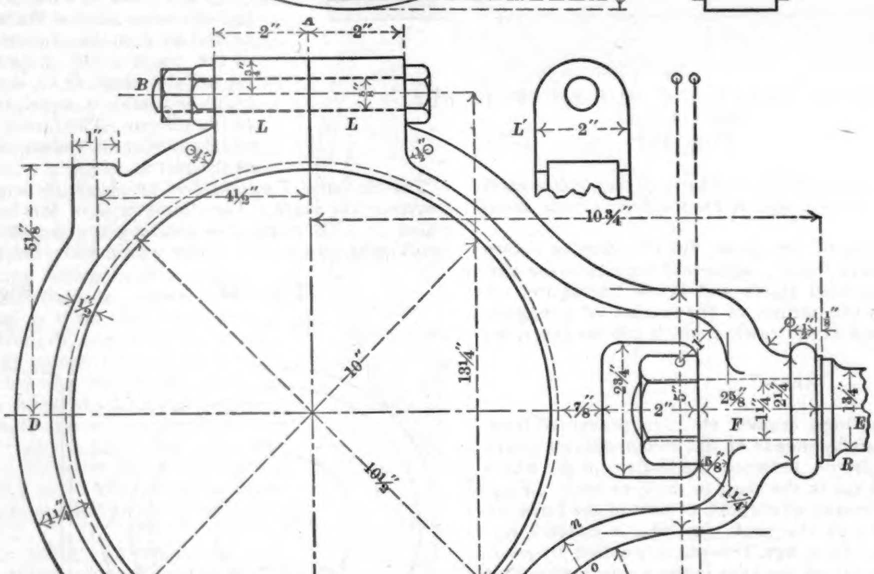
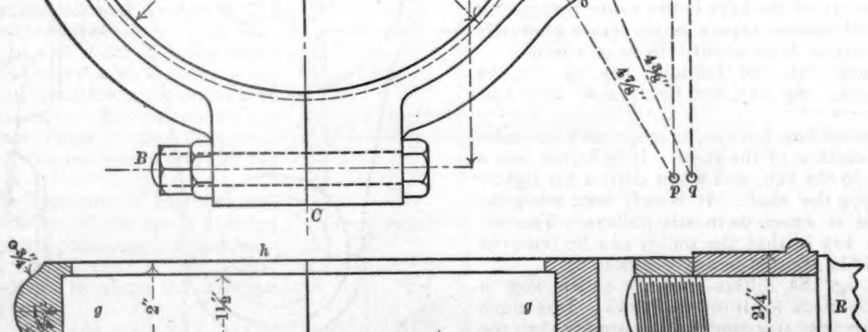


Fig. 192.



ECCENTRIC STRAP.

Scale ¼ in. = 1 in.

The diameter *D* of the shaft inside of the hub of the crank is 4¼ in. Just back of the crank it is 4⅝ in., a shoulder being turned on it to limit the movement of the crank. The crank-pin where it fits into its hub is made either straight or slightly tapered, and is driven or pressed into the boss and riveted on the back side of it.

The key in the shaft is proportioned in the same way as the

keys for pulleys—that is, *its width $W = \frac{1}{4}$ the diameter D of the shaft $+ \frac{1}{8}$ in., and its thickness is equal to one-half its width.*

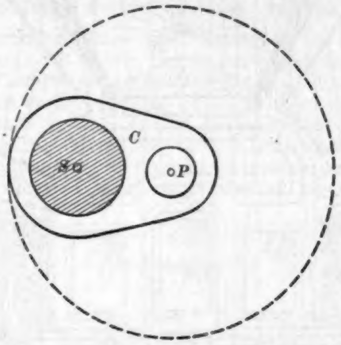
The student should draw a crank half size for a shaft $4\frac{1}{2}$ diameter, and calculate its proportions from the rules given, and mark all its dimensions on the drawing.

ECCENTRICS.

The chief use of the eccentric is in the steam-engine, where it is employed to work the valves. It has been defined as a crank in which the crank-pin is large enough to embrace the crank-shaft. Thus, let *C*, fig. 188, be a small crank, *S* the shaft, and *P* the crank-pin. If we simply increase the diameter of the pin to that of the dotted circle, so as to embrace the shaft, the crank becomes an eccentric.

The advantage which an eccentric has over a crank is that an eccentric can be put on a shaft in any position, without altering

Fig. 188.



the form of the shaft, whereas, if a crank is used, the form of the shaft must be changed, or its continuity must be broken to form the crank.

The portion of the eccentric which corresponds to the crank-pin, and which embraces the shaft, is called the *sheave*. This is generally made of cast iron. Figs. 189 and 190 represent a side and front view of an eccentric for the engine described in the beginning of this chapter. Such eccentrics are usually made of cast iron. They are drawn from two centers, *a* and *b*—*a* is the center of the shaft and *b* that of the sheave.

The distance from the center *a* of the shaft to *b*, that of the sheave, is called the *radius* of the eccentric. The *throw* is twice the radius.

A ring of metal called an eccentric-strap, represented by figs. 191 and 192, is made to fit the outside of the eccentric accurately, and is connected to the valve gear by a rod, called an *eccentric-rod*, one end of which is shown at *E*, fig. 191. By this means the motion of the eccentric is transmitted to the valve.

The strap in nearly all cases is divided into two halves, their line of separation, *A C*, being at right angles to the center-line *D E* of the eccentric-rod. The two halves are held together by bolts *B B*. The straps are also made of cast iron.

The rod *R* is fastened to one part of the strap by a nut, as shown in the figures, or in some cases by bolts.

The hub of the eccentric is bored out to fit the shaft, and is fastened to it by set screws *s s*, fig. 189.

The student should draw the eccentric and strap either full or half size. In doing this he should first draw a horizontal center-line *c d*. On this line he should lay down the center *a* of the shaft and *b* of the sheave, at a distance apart equal to the radius—in this case 2 in. From the center *a* he can then draw a circle whose diameter is equal to that of the shaft, or $4\frac{3}{8}$ in. From *b* the circles representing the circumference or periphery, *c e f*, of the eccentric, can be drawn. From fig. 190 it will be seen that the central part *i j* of the periphery is made larger in diameter than the outer edges. This larger portion fits into a groove in the straps shown at *g g*, fig. 192, which is a sectional plan drawn on the line *D E* of fig. 191. The strap has shoulders, *h h*, which fit the portions of the periphery of the eccentric which are shown at *i* and *j*, fig. 190, and are of smaller diameter than the central part. The object of the shoulders is to hold the eccentric straps in their place on the eccentric. Sometimes the central part of the eccentric is made smallest in diameter, but the method shown in the engraving is considered the best, because it gives the whole width of the eccentric for bearing surface, and protects the latter more perfectly from dust and dirt, and the groove *g g*, fig. 190, in the straps holds oil better than a groove in the eccentric will.

The eccentric has an arm *k*, fig. 189, the section of which, in this instance, is made of **T** form, as shown by the dotted lines in fig. 190. The rim is made $\frac{5}{8}$ in. thick, as shown at *f*, fig. 189. After drawing the arm *k* and the circle representing the inside of the rim, they should be joined together and to the hub of the eccentric by arcs of circles, or *fillets*, as they are called. In the engraving these are all of $\frac{1}{4}$ in. radius.

The set-screws *s s* are both located on center lines *a l* and *a m*, which are drawn at angles of 45 degrees to the center line *c d*. Bosses or projections are made on the hub, so as to give a greater length for the bearing of the threads of the screw. These bosses are not shown in fig. 190, as their delineation involves principles of projection which have not yet been explained, but will be taken up in another chapter.

The inside and the outside of the eccentric straps, figs. 191 and 192, are drawn from the same center. The centers of the bolts *B B* are located $13\frac{1}{4}$ in. apart. Half this distance should be laid off on each side of the center line *D E*, and the bolts should be drawn on center lines passing through the points thus laid down. Lugs or projections *L L* are cast on each of the straps, to receive the bolts *B B*. An end view of one of these lugs is shown at *L'*.

The method of drawing the boss *F* to receive the eccentric-rod hardly needs explanation. The positions of the vertical lines, which define its limits, are indicated by the figures, and should be laid down on *D E*, and the horizontal lines should be laid off on each side of *D E*. After the straight horizontal lines are drawn, their intersections with the vertical lines should be joined by arcs of circles, as shown. The curves *n* and *o* are drawn from centers *p* and *q*, which are located on perpendicular lines drawn from *D E*, as shown. Owing to the small size of the engravings, they *appear* complicated. This appearance will vanish when the student lays them down to a larger scale and has more room on the paper.

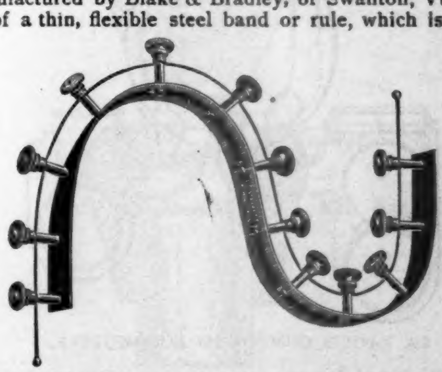
In making these drawings, he should remember that every line and curve which is drawn must be reproduced on the patterns. For this reason, the radii and centers of all curves should be indicated. In cases where there are a number of curves which are alike, it is sufficient to indicate the center and radius of one of them.

A draftsman cannot be too particular, either, in giving all the dimensions on a drawing, but he should be especially careful to give the important ones. It is not an unusual occurrence to find that all the minor dimensions have been given, and one or more of those which are most essential omitted. The caution will be repeated here that after the drawing is finished and the dimensions have been marked on it, the person who made it should go all over it with his scale, to see whether the dimensions and the measurement agree with each other. Serious errors can often be detected in this way.

(TO BE CONTINUED.)

Flexible Curve-Rule.

THE engraving herewith represents an ingenious rule for drawing irregular curves. It can be adjusted to any desired form and is the invention of Mr. E. T. Bradley. These rules are manufactured by Blake & Bradley, of Swanton, Vt. They consist of a thin, flexible steel band or rule, which is divided



BLAKE & BRADLEY'S CURVED RULE.

into a scale of inches. To this studs are rigidly attached by riveting them to the band. Each of the studs has a hole near its upper end through which a wire passes loosely. It also has a set-screw on its upper end with a knurled head, and the end of the screw bears on the wire. When the screws are loose the wire can slide easily in the holes, and the steel band is then entirely flexible, and can be bent to conform to any curve. When the screws are tightened the wire braces or stiffens the band so that it becomes rigid and holds it in any desired position, and it can then be used as a ruler. Its uses will be obvious to any experienced draftsman who has been compelled to whittle out templates for drawing curves, which could not be drawn with any of these harassing " hard rubber curves" which are sold by instrument makers. The flexible curve seems to

be a very valuable instrument for architects, designers, draftsmen, and pattern makers, especially those engaged in marine work or in drawing or measuring various irregular curves of any kind. One of its uses was suggested in some experiments made some time ago to determine the proper shape for a carseat back. To do this a box similar to a large arm-chair was constructed, and several different persons' forms were moulded in it in sand. A pasteboard template was then cut to fit the form thus left in the sand. The instrument herein described could have been adjusted to the impression left in the sand and could have been quickly and easily transferred or reproduced on paper. For carriage makers or car-builders, or, in fact, designers generally it will be very useful. The expression is not very new or original, but it has the merit of being true that this rule "fills a long-felt want."

The rules are made of two different qualities, one for work when great precision is needed, the other for coarser uses. Three sizes of each quality are also made. The rules of the first quality are 12, 18, and 24 in. long, those of the second 24, 36, and 48 in.

Recent Patents.

LA PAGE'S COMPOUND LOCOMOTIVE.

THIS invention, which is covered by patent No. 431,899, issued to Richard Herbert La Page, of Westminster, England, is shown in figs. 1 and 2; it refers chiefly to the arrangement of the cylinders, in which two low-pressure cylinders of smaller size are substituted for one large one, in order to obviate the objections made to the use of a very large cylinder.

FIG. 1.

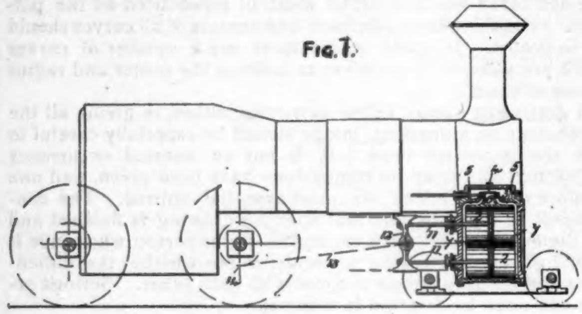
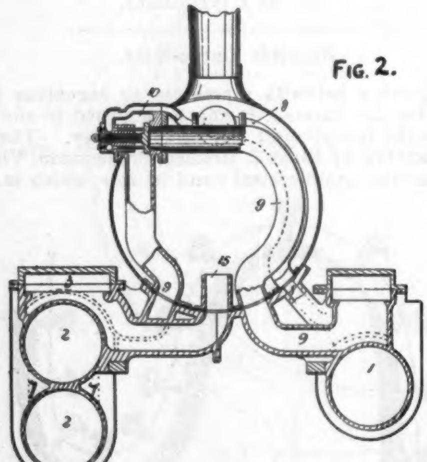


FIG. 2.



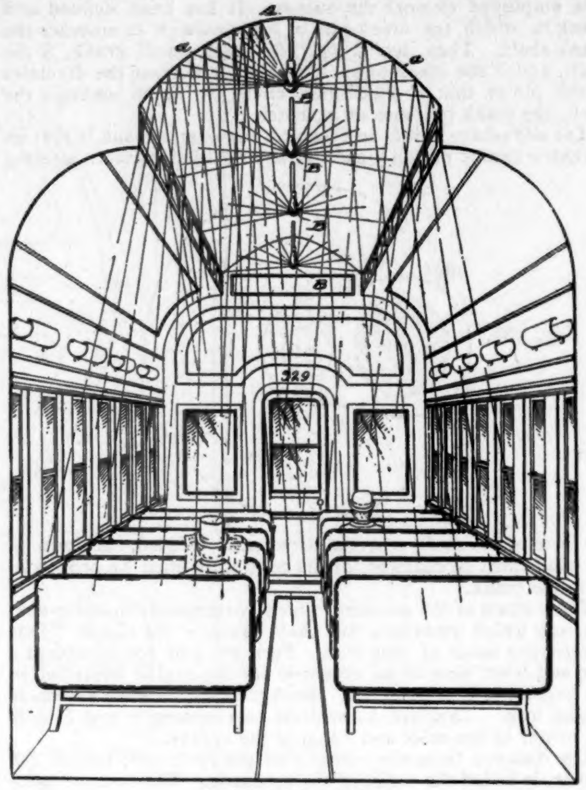
LA PAGE'S COMPOUND LOCOMOTIVE.

Fig. 1 is an elevation of a locomotive and fig. 2 a cross-section, on a larger scale. In these 1 is the high-pressure cylinder; 2 2 the low-pressure cylinders; 3 the steam-chest; 4 the valve; 5 6 the ports; 7 the connecting passages between the low-pressure cylinders; 8 the steam-pipe to the high-pressure cylinder; 9 the connecting-pipe which carries steam from the high-pressure to the low-pressure cylinder; 15 the blast-pipe or exhaust common to both low-pressure cylinders.

The connecting steam-pipe 9 may be fitted with a valve-case 10, containing combined intercepting and starting valves constructed to operate in an automatic manner. The pistons of the two low-pressure cylinders are connected by their rods 11 to one slide-block or cross-head 12, that is guided in the ordinary manner and coupled to one end of a connecting-rod 13, the other end of which is coupled to the crank-pin 14 of the driving-shaft in the usual manner.

KOYL'S CAR-ROOF.

The accompanying illustration shows a form of car-roof which is covered by Patent No. 436,361, issued to Charles Herschel Koyl, of Easton, Pa. The invention is designed to improve the lighting of railroad cars and similar structures.



KOYL'S CAR-ROOF.

The inventor claims that in cars, as usually built, the lamps are placed in the center and a little below the ceiling, and much of the light is thus lost. To remedy this he proposes to make the car-roof, or at least its interior face, parabolic in cross section, the object being to reflect downward upon the passengers the light which would otherwise be lost. With this shape he combines the placing of the lamps or other lights at a focal distance from the ceiling; that is to say, in the lines of the foci of the parabolic curves which give the contour to the roof. The illustration shows a cross-section of a car in which the curvature is confined to the interior of the dome or raised central portion *A* of the car-roof. The interior surface of this portion of the roof is parabolic in cross-section, as shown by the curves *a a*, but with no longitudinal curvature. In the line of the foci of the parabolic curves are placed at proper intervals the incandescent electric lights *B*. With this arrangement the upward rays from the lamps, which would otherwise be lost in the ceiling, are reflected downward in nearly parallel course, as shown by the dotted lines, in such a way as to aid the direct downward rays, and to about double the available light.

Manufactures.

Marine Engineering.

THE engine which the Cleveland Ship Building Company will build, together with boilers and wheels for the side-wheel steamer, to be built this winter by the Craig Ship Building Company, of Toledo, will be a novelty in this section of the country. The engine is an inclined triple-expansion, having cylinders 26, 42 and 66 in. diameter by 6 ft. stroke, directly connected to three double cranks, set at an angle of 120° to each other. It will be provided with steam reversing engine and independent air pumps, and will turn feathering side wheels 19 ft in diameter at a rate of 40 revolutions a minute. The engine will be supplied with steam by two boilers, of the gunboat type, 11 ft. diameter and 21 ft. long, with three furnaces each, and will be allowed 160 lbs. working pressure. This

arrangement does away with the heavy cumbersome gallows frame, walking beam, and heavy connecting rod, and will secure an even, steady turning of the wheels, thereby obviating the jerky motion of the ordinary beam engine. It is expected by the builders to drive the proposed boat no slower than the fastest, to say the least. The company also contracted recently for the construction of two immense tanks 6½ ft. inside diameter and 104 ft. long each, made of ¾-in. steel plate. These are to be delivered in New York in about 90 days.—*Cleveland Marine Review.*

THE Risdon Iron & Locomotive Works, San Francisco, have recently completed an overhauling of the Pacific Mail steamer *City of Sydney*. The work included general repairs of the engines and the building of six new boilers, each 13 ft. in diameter and 10 ft. 6 in. in length, each boiler having three corrugated furnaces 36½ in. in diameter and 7 ft. 6 in. long. These boilers are built for a working pressure of 80 lbs.

THE arrangements have been completed for the transfer of the Roach Yards at Chester, Pa., to the Roach Ship Building & Engineering Company, Limited. This is an English concern, although a part of the capital is owned in this country, and purchases the yards at Chester with the other property controlled by the Company. Of the eleven directors, four reside in this country, including John B. Roach, the present head of the concern, and George E. Weed, President of the Morgan Iron Works, in New York.

Locomotives.

THE Brooks Locomotive Works, Dunkirk, N. Y., have orders for 60 locomotives for the Atchison, Topeka & Santa Fé Railroad.

THE traffic through the St. Clair tunnel on the Grand Trunk Road will be worked by locomotives built especially for that service. These are tank locomotives of the Decapod type, and are now under construction at the Baldwin Locomotive Works in Philadelphia. They have boilers 74 in. in diameter, with 280 tubes 2½ in. in diameter and 13 ft. 6 in. long. The fireboxes are 11 ft. long and 3½ ft. wide. The working pressure will be 160 lbs. The cylinders are 22 in. in diameter and 28 in. stroke; there are five pairs of driving wheels 49 in. in diameter. One of these engines will weigh in working order, including 1,800 galls. of water in the tank, about 90 tons.

Cars.

THE Lehigh Car & Manufacturing Company, Stemton, Pa., has just completed 400 box cars for the Charleston, Sumter & Northern, and is building 100 freight cars for the Lehigh & Hudson River Railroad.

THE Oregon Equipment Company is building a number of freight cars for different roads at its shops in Seattle, Wash.

THE Jackson & Sharp Company, Wilmington, Del., has recently built a number of passenger cars for export, some of them going to France and some to Spain.

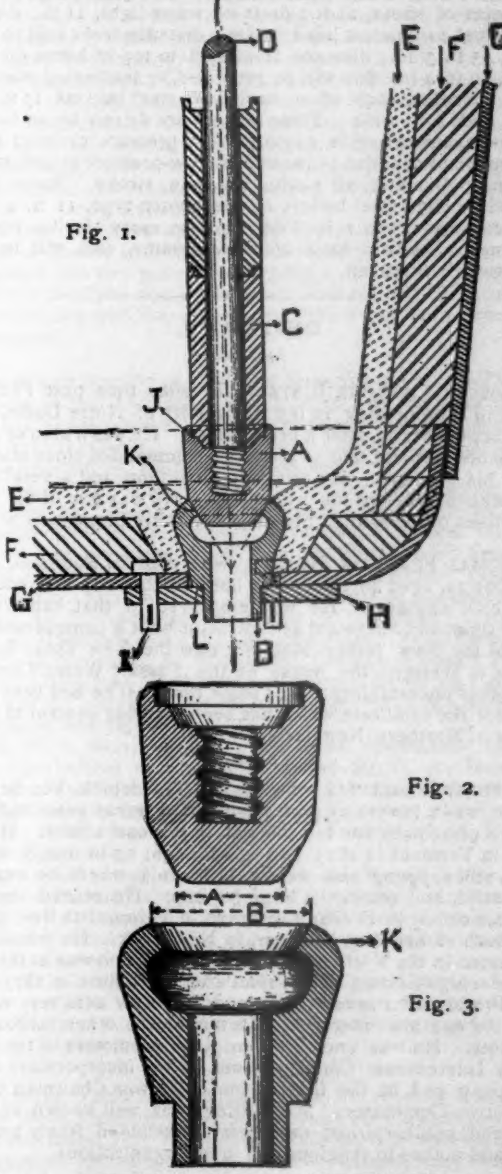
THE Westinghouse Air-Brake Company has completed its removal to the new shops in Wilmerding, Pa., where the general offices are also located, although a city office will be maintained in Pittsburgh. The old shops in Allegheny City are now occupied by the Fuel Gas & Manufacturing Company, which is also a Westinghouse concern.

Griffith's Steel Ladle.

THE accompanying illustration shows a stopper and nozzle for open-hearth and Bessemer steel ladles. Fig. 1 is a section through a portion of the ladle; fig. 2 is an enlarged section of the stopper, and fig. 3 of the nozzle.

In fig. 1, *G* is the shell of the ladle; *F* the permanent lining of fire-brick, which is allowed to remain in the ladle an indefinite length of time; *E* is the temporary lining, composed of loam or of fire-clay and sand, which seldom lasts more than one week; *D* is the stopper-rod, screwed into the stopper *A*, and covered with a fire-clay sleeve *C*. The stopper *A* is shown on a larger scale in fig. 2. The nozzle *B*—shown on a larger scale in fig. 3—passes through the shell of the ladle, the shoulder *L* resting on the nozzle-plate *H*, which is fastened to the ladle by three cotter-bolts *I*.

The inventor's directions for using this device are as follows: "In preparing a stopper, if the rod and gooseneck are welded together in one piece, first slip over the rod a wrought-iron washer with an inside diameter of 1¾ in., or ⅛ in. larger than the diameter of the rod, then the requisite number of stopper-rod sleeves, after which gently but firmly screw the stopper on to the end of the rod. After this has been done stand the rod on end and carefully allow the sleeves to slip down into position, placing a small quantity of moderately stiff clay between the joints *J* to make them perfectly secure. After they are all in position, slip the washer down upon the top sleeve and secure it by driving three eightpenny nails between it and the rod, placing them 120° apart. A straight rod that is secured to the gooseneck by jamb-nuts can be made up in the same manner, or it can be made up independent of the gooseneck and



GRIFFITH'S STEEL LADLE NOZZLE.

secured to it just prior to using. To insure success the ladleman must not use too much force in screwing the stoppers fast or he will strip the threads out from them. He must also carefully inspect the screws after they have been used, preferably by screwing a standard nut over them to be sure that the thread is not distorted or lumpy. The thread on the rod should be a trifle smaller than that in the stopper.

"In lining the ladle keep the fire-brick lining 5 or 6 in. away from the nozzle, and fill the space thus formed with the loam lining, chamfering it off around the nozzle as shown in sketch. This will enable the ladleman to renew the nozzle much more rapidly than if the fire-brick lining is run up close to the nozzle.

"In open-hearth practice we do not advise the use of either the

stopper or nozzle for more than one heat, and although it can be successfully accomplished, it is not an economy in the end."

The advantages claimed for this device are that it prevents leakage, and will not burn off while in use.

A New Sound Steamer.

THE new steamboat *Plymouth*, built for the Old Colony Steamboat Company by the W. & A. Fletcher Company, of New York, has had her preliminary trial trip. The *Plymouth*, which is to run in the Fall River Line on Long Island Sound with the *Puritan* and the *Pilgrim*, has the following dimensions: Length over all, 366 ft.; length on water line, 351 ft. 8 in.; breadth over guards, 86 ft.; breadth of hull, 50 ft.; depth at lowest point of sheer, 21 ft.; draft of water light, 11 ft.; distance from keel to topmast head, 119 ft.; distance from keel to dome deck, 55 ft. 3 in.; distance from keel to top of house on dome deck, 59 ft. 4 in. She will be propelled by feathering wheels 30 ft. in diameter, each wheel having 12 steel buckets 13 ft. 3 in. long and 4 ft. wide. These wheels are driven by an inclined triple-expansion engine having a high-pressure cylinder 47 in., intermediate cylinder 75 in. and two low-pressure cylinders each 81½ in. in diameter, all having 8 ft. 3 in. stroke. Steam is furnished by eight steel boilers of the Scotch type, 11 ft. 4 in. in diameter and 13 ft. 1 in. long, built to carry 160 lbs. working pressure. She will have 250 state-rooms, and will be very handsomely fitted up.

OBITUARY.

PROFESSOR ARTHUR J. STACE, for some time past Professor of Civil Engineering in the University of Notre Dame, Ind., died September 25, after a brief illness. He was a man of active and acute intellect, and as a teacher commanded close attention from his students. He was also an author, and several of his books have attracted much attention. He was one of the representatives of the United States at the Paris Exposition in 1889.

THOMAS FRANKLIN HOXSEY, who died in Paterson, N. J., October 14, aged 49 years, was born in that city and educated as a civil engineer. He was employed in that capacity for some time, and afterward as contractor built a considerable section of the New Jersey Midland, now the New York, Susquehanna & Western, the works of the Passaic Water Company and other undertakings. For some time past he had been Manager for the syndicate which has been securing control of water rights in Northern New Jersey.

FREDERICK BILLINGS, who died in Woodstock, Vt., September 30, was a lawyer by profession, but of recent years had been known principally for his interest in railroad affairs. He was born in Vermont in 1823, and was brought up in that State, but when still a young man went to California, where he was very successful, and amassed a large fortune. He retired from the practice of law in 1866 and returned to Vermont to live, spending much of his time, however, in New York. He was largely interested in the Northern Pacific Railroad, and was at the head of the reorganization of that road after the failure in 1873. He was President for several years and a director until very recently. He was also interested in a number of other railroad enterprises. He was one of the original promoters of the Nicaragua Interoceanic Canal, was one of the incorporators of the Company, and at the time of his death was Chairman of the Executive Committee. Mr. Billings was well known as a liberal and public-spirited man, who contributed freely both his time and means to religious and other organizations.

RICHARD N. ALLEN.—The news of the sudden death of Richard N. Allen, the President of the Allen Paper Car Wheel Company, has been the cause of grief and sadness to a large circle of his friends, who are to be found in all parts of the country. He died of heart disease at his home in Cleveland on October 7. His life was a typical example of the kind of career which is, or was, open to all American youths. He was born near Springfield, Mass., in 1827. He began as a fireman of a locomotive on the Connecticut River Railroad at the age of 18, and when he was 19 he was promoted to the position of engineer.

In 1852 Mr. Allen moved to Cleveland, O., and ran a locomotive on the Cleveland & Toledo Railroad, but was soon after promoted to the position of Master Mechanic of the northern division of the road with headquarters at Sandusky. At Cleveland he was riding in a locomotive the boiler of which exploded and killed the engineer and fireman, and seriously injured him, so that he was carried home on a stretcher and given up for dead. He recovered, however, but bore the marks of his injuries all his life.

He moved south soon after and became Master Mechanic of the New Orleans, Jackson & Great Northern Railroad. During the war his connection with that road was broken up, and he finally returned to Cleveland. He then invented a car journal-box and a barrel to contain oil, and afterward tried his fortunes in the oil regions of Pennsylvania and sank several wells, with what success is not known.

After this he was induced to take an interest in a straw-board mill at Pittsford, Vt., which was not profitable, and the whole enterprise finally fell into Mr. Allen's hands. He then conceived the idea of making the centers of car-wheels of compressed paper or straw-board, and finally made a model of such a wheel. The chief difficulty consisted in holding the tire on the wheel, and after this was overcome in inducing any railroad companies to try the wheels, and thus get them into practical use. Finally the officers of the Rutland & Burlington Railroad were induced to try a set under a light car. After a time he went to Hudson, N. Y., and engaged in the manufacture of the wheels there. He still had difficulty in holding the tires to the wheels, and like most other new inventions it was some years before it was perfected to the inventor's satisfaction. He spent some time at the Krupp works studying the problem. He finally induced Mr. George M. Pullman to interest himself in the wheel, and to adopt it for the sleeping cars of the Pullman Company. Aided with the capital and enterprise of Mr. Pullman extensive works for the manufacture of the wheels were established at Hudson, N. Y., and at Pullman, Ill. Many thousands of these wheels are in use, which fact is testimony of the success of Mr. Allen's invention. Recently he had been engaged in improving his paper wheels and adapting them for street-car service.

Mr. Allen was of a singularly gentle and kindly disposition, which made him a deserved favorite among the people with whom he came in contact, and he had the reputation among those who had opportunities of judging of being scrupulously just and fair in his transactions with others—a reputation difficult to maintain by any one engaged in the tortuous ways in which business with some railroad companies and officers must be conducted. Mr. Allen's death is an irreparable loss to his many friends and acquaintances who were encouraged by his cheerful ways and character, and gladdened by his friendship and good-will.

PERSONALS.

HENRY C. ALLEN has been appointed City Engineer of Syracuse, N. Y. He has been Deputy City Engineer for some time.

GEORGE D. HARRIS, late on the Richmond & Danville Railroad, is now Master Mechanic of the Georgia Southern & Florida Railroad.

A. RICCIO, late Chief Engineer of the Georgia Pacific, is now Chief Engineer of Construction of the Georgia, Carolina & Northern Railroad.

T. M. T. MCKENNAN is now Chief Engineer in charge of location and construction of the new Tennessee River, Ashville & Coosa Railroad in Alabama.

THOMAS L. CHAPMAN is now Mechanical Engineer of the Iron Car & Construction Company, of New York. He was recently with the Central Railroad of Georgia.

H. P. LATTA has been appointed Master Mechanic of the Chicago & Erie Railroad, with office at Huntington, Ind. He was formerly on the Lake Shore road.

CHARLES B. COUCH, late Superintendent, has been appointed Purchasing Agent of the Lake Shore & Michigan Southern Railway, succeeding L. C. HIGGINS, deceased.

L. C. NOBLE, General Master Mechanic of the Houston & Texas Central Railroad, will retire from that position to engage in the business of manufacturing and introducing the nut-lock which he has invented and patented.

JAMES F. GODDARD has been appointed to the position of Commissioner of the Trunk Lines Association, which has been vacant since the resignation of Mr. Albert Fink. Mr. Goddard has had an extended experience as a traffic manager.

MAJOR H. WADSWORTH CLARKE has resigned his position as City Engineer of Syracuse, N. Y., on account of ill health.

Major Clarke has been an exceedingly capable and conscientious officer, and his illness is largely due to overwork while in office.

WILLIAM SMITH has been appointed Superintendent of Motive Power of the Chicago & Northwestern Railway, to succeed the late Mr. G. W. Tilton. Mr. Smith was for three years Mr. Tilton's assistant, and was previously a division master mechanic on the road.

A. J. CASSATT, of Pennsylvania; HENRY G. DAVIS, of West Virginia, and GEORGE M. PULLMAN, of Illinois, have been appointed by the President Commissioners on the part of the United States to locate and organize the Intercontinental Railroad, as provided at the recent Pan-American Conference.

CHARLES MACDONALD, the well-known bridge engineer, has presented to the Rensselaer Polytechnic Institute a fund sufficient to yield $120 yearly, which is to be given to the student presenting the best graduating thesis containing an original design or an original investigation of some process of interest to engineers.

J. A. DAVENPORT is appointed Engineer of Maintenance of Way of the Georgia Pacific Railroad, having charge of the First Division, from Atlanta, Ga., to Birmingham, Ala. J. C. MOTLEY is also appointed Engineer of Maintenance of Way, having charge of the Second Division, from Birmingham, Ala., to Columbus, Miss. The office of Chief Engineer is abolished.

J. T. HARAHAN has been chosen Second Vice-President of the Illinois Central Railroad Company, and will have charge of the operation and maintenance of the road. He has served on the Louisville & Nashville, the Chesapeake & Ohio, the Lake Shore & Michigan Southern, and other roads, and was recently General Manager of the Louisville, New Orleans & Texas Railroad.

PROCEEDINGS OF SOCIETIES.

American Institute of Mining Engineers.—The 57th meeting began in New York, September 29. After the usual opening proceedings a paper on Explosions from Unknown Causes was read by J. C. Bayles. This was followed by papers on the Use of Electricity in Mining, Metallurgy, etc., by John C. Fowler, F. H. McDowell, C. Jones, C. M. Ball and others, and by a paper on the Iron Mountain Mine, by Professor William B. Potter. A number of papers were also read by title.

On September 30, two sessions were held, both being devoted to the reading of papers. Those read included one on Electric Power Transmission in Mines, by H. C. Spaulding; on the New Drifton Breaker, by Eckley B. Coxe; on Machinery for Charging Furnaces, by S. T. Wellman; on Pneumatic Hoisting, by H. A. Wheeler; on Copper in the United States, by James Douglas, Jr., and on Recent Improvements in German Steel Works, by R. M. Daelen, of Dusseldorf, Germany. A number of other papers were also read by title, and Mr. A. Fteley decribed the principal features of the New Croton Aqueduct.

This concluded the separate meeting of the Mining Engineers, the remainder of the meetings being held in connection with the British Iron & Steel Institute.

Iron & Steel Institute.—The first session of the American meeting began in New York, October 1, and was practically devoted to addresses of welcome from American Engineers and manufacturers and to appropriate responses from the visitors. Sir James Kittson also made the Presidential address, and announcements were made of the programme prepared for by the local committee.

A number of papers were also read, including one by James Gayley on American Blast Furnaces and another by Burdett Loomis on Fuel Gas. Both of these papers were discussed at great length by the American and Foreign engineers. Professor Henry M. Howe read a paper on the Bessemer Process; Professor E. Thomson one on Electric Welding, and Dr. C. B. Dudley one on the Wear of Metal as Influenced by Its Chemical and Physical Properties. A number of other papers of much interest were also presented and read either in full or by title.

On Thursday, October 2, the ceremonies attending the dedication of the Holley Memorial took place. In the afternoon an address was delivered in Chickering Hall by Mr. James Dredge, Editor of *Engineering*, who was long an intimate acquaintance of Mr. Holley, and who made an interesting address. The remaining ceremonies took place in Washington Square, where the memorial is placed; it is a colossal bronze bust by J. Q. A. Ward, placed upon a handsome pedestal, with appropriate inscription.

In the evening the annual banquet of the Iron & Steel Institute took place at Delmonico's.

On October 3 the members separated into parties and spent the day in visiting points of interest in the city and its neighborhood. On the morning of October 4 they started for Philadelphia in two special trains. In that city they were received by the Local Committee, Mr. Joseph D. Potts, the Chairman, making an address of welcome, which was responded to by Sir James Kittson. After lunch the members were taken by steamboat to Chester, Wilmington and other places on the Delaware.

Monday, October 6, was devoted to visits to various manufacturing establishments in Philadelphia and neighborhood, and October 7 to a trip to Lebanon, Pa., the Cornwall Iron Mines and blast furnaces and Mount Gretna Park.

The International Meeting, which included members from the British, American and German Societies was held in Pittsburgh October 9 and 10. After the opening proceedings a large number of papers of much interest were read, including a letter from Sir Henry Bessemer, giving an account of the discovery of the Bessemer process; one by Sir Lowthian Bell on the Probable Future of the Iron Manufacture; one by Sir Nathaniel Barnaby on the Protection of Iron and Steel Ships; on the Marine Engine, by A. E. Seaton; Dr. Hermann Wedding on German Practice with Iron and Steel; Professor John W. Langley on International Standards for Analysis of Iron and Steel and others, all being discussed.

Considerable time was spent by the members in visiting the points of interest in Pittsburgh and vicinity. At this point they separated into two parties, one going westward to Chicago and the other South to visit the coal and iron regions of that section in accordance with the programme which had been previously announced.

American Society of Railroad Superintendents.—The 19th meeting of this Association was held in New York, October 7, with a large attendance. The Secretary and Treasurer presented their annual reports. The Executive Committee made several recommendations, which were approved.

The following officers were elected for the ensuing year: President, H. Stanley Goodwin, Lehigh Valley Railroad; First Vice-President, R. G. Fleming, Savannah, Florida & Western; Second Vice-President, C. W. Bradley, West Shore; Secretary, C. A. Hammond, Boston, Revere Beach & Lynn; Treasurer, R. M. Sully, Atlantic Coast Line; Members of Executive Committee, C. S. Gadsden, Charleston & Savannah; O. E. McClellan, Pennsylvania; O. M. Sheppard, New York, New Haven & Hartford; A. B. Atwater, Chicago & Grand Trunk.

The Committee on Machinery made a report on Car Heating, and the system of the Morton Safety Heating Company of Baltimore was explained.

Mr. W. G. Wattson read a paper on Systematic Handling and Distribution of Freight Cars, and Mr. C. A. Hammond read one on Signalling. The latter was discussed and it was resolved to appoint a Committee on Signalling, the President naming F. K. Huger, J. J. Turner, J. Donelly, C. H. Platt and C. A. Hammond.

At the afternoon session Mr. H. H. Westinghouse read a paper on Recent Improvements in Air-Brakes, which was discussed by the meeting. Mr. James Churchward read a paper on Rail Fastenings. The remainder of the session was taken up by a discussion on Train Rules.

Several changes in the Constitution were proposed, which under the rules will not be acted upon until the next meeting. The thanks of the Society were voted to the retiring President, Major Gadsden.

General Time Convention.—The fall meeting was held in New York, October 8. The day fixed for the change of time was November 16. The Executive Committee reported that 169 companies, operating 121,442 miles of railroad, were now members of the Convention.

The President, Colonel H. S. Haines, made an address in which he suggested some improvements in train rules, and also spoke of the importance of adopting the *per diem* system of payment for cars. He also referred at some length to the important work of the Committee on Safety Appliances.

The Car Service Committee made a report giving statistics of car movement from a number of roads. It was stated that there are now 27 demurrage associations in successful operation, the form of agreement suggested by the Time Convention being generally adopted. The Committee recommended no action concerning *per diem* service payments.

The Committee on Safety Appliances made a long report submitting a synopsis of the Legislation adopted in the United States on Safety Appliances. The Committee recommended the adoption of the Master Car Builders' automatic coupler as the

standard for all members of the Convention. The next subject to be taken up will be that of Train Heating, upon which careful investigations will be made during the coming winter. This report was adopted with only two negative votes. The Committees on Car Service and Safety Appliances were continued with the same members.

American Society of Civil Engineers.—At the regular meeting, October 1, invitations were received to join in the meetings and excursions of the Institute of Mining Engineers and the Iron & Steel Institute. The Secretary announced the death of several members.

A paper, by J. F. Le Baron, on the Fallacy of the Contract System of Government Land Surveys, was read and discussed.

The tellers announced the following elections: *Members:* G. Aertsen, Latrobe, Pa.; William S. Bacot, New York; George J. Bailey, Albany, N. Y.; Charles B. Ball, Washington; Percy M. Blake, Hyde Park, Mass.; John B. Bott, Albert N. Connett, Baltimore, Md.; Herbert F. Dunham, Cleveland, O.; Oscar A. F. Saabye, Roanoke, Va.; Archibald A. Schenck, New York; Hood Tucker, White Story, Tenn.

Associate: P. H. Griffin, Buffalo, N. Y.

Juniors: Robert A. Cummings, Roanoke, Va.; Charles R. Beltes, Hoboken, N. J.; Richard S. St. John, Princeton, N. J.; Homer R. Stanford, St. Louis, Mo.; William C. Hawley, Chicago, Ill.; Ezra B. Naylor, New York.

AT the meeting of October 15, Mr. W. E. Worthen presented a paper on Steam Heating. Mr. J. B. Francis made some supplementary remarks on the same subject, which was further discussed by a number of members present.

Boston Society of Civil Engineers.—At the regular meeting, October 15, Mr. E. S. Dorr exhibited and explained a diagram for determining sizes of sewers.

Mr. A. F. Noyes and Mr. H. D. Woods described the additions to the Newton Water Works with reasons for building the same.

Mr. H. H. Carter read a paper on the Settlement of Large Embankments, with special reference to the one between Moon Island and Squantum in Boston Harbor. All these papers were discussed.

Engineering Association of the Southwest.—At a meeting held in Chattanooga, Tenn., October 10, the Committee on the Cause of Setting of Cement submitted a report prepared by Dr. W. L. Dudley, of Nashville.

Mr. James A. Fairleigh gave an account of the new Tennessee River Bridge at Chattanooga, illustrated by drawings and maps. This was discussed at some length.

Messrs. Joseph C. Guild and William Bowron explained the Geology and Mineral deposits of the Chattanooga districts to visiting members.

Western Society of Engineers.—At the regular September meeting in Chicago, R. B. Bourland, C. F. T. Kandeler, Edward L. Abbott and Charles H. Miller were elected members.

The special topic for the meeting was the Site of the World's Fair, which was discussed at great length by members present.

Denver Society of Civil Engineers & Architects.—The Annual Convention of this Society was held at Manitou, Col., October 10, and continued on the following day. The members left Denver on the afternoon of October 10 and held their first session in the evening of that day. On the following day another meeting was held and a trip over the Pike's Peak Railroad was taken. Other places of interest in the neighborhood of Manitou were also visited, and the Convention closed with the annual supper in the evening.

Technical Society of the Pacific Coast.—At the regular meeting, September 5, in San Francisco, Mr. Calvin Brown read a paper on Calcareous Cements, giving investigations both chemical and experimental into the nature of such cements. The paper was accompanied by a number of photographs of cement and concrete work erected in France.

AT the regular meeting, October 3, Mr. H. C. Behr read a paper on Experimental Works for Ores Requiring Forced Concentration, which had a special interest for those engaged in mining.

Master Car Builders' Association.—A circular from Secretary John W. Cloud announces the result of the letter ballots ordered at the last Convention.

The Journal-box for 60,000 lbs. cars and the Lid for the ordinary journal-box were rejected, not having received a two-thirds vote.

The following standards were adopted, all having received a considerable vote over the necessary number: Method of Loading Logs and Poles on Cars; Racking Cars for Loading Bark; Height of Draw Bar for Passenger Equipment Cars, 35 in.; Safety Chains for Passenger Equipment Cars; Brake Beam Lever, Lateral Angle 40°; Fitting for Train Pipe for Steam Heating; Two-Inch Female, Standard Pipe Thread.

Master Car & Locomotive Painters' Association.—The Annual Convention of this Association, which was held in Boston in September, was largely attended, and much practical work was done there. Among the questions discussed were the Benefit to an Undercoat of Paint of an Egg-shell Gloss; Best Method of Testing Japan; Treatment of Hard and Soft Woods; Best Paint for Preventing Rust on Metal; Best Method of Removing Old Paint; Most Economical Method of laying Gold Leaf; Durability of Varnish; Hard and Soft Wood Finish; Tests of Paint and Varnish; Striping and Lettering; all interesting and practical topics.

It was decided to hold the next Convention at Washington. The following officers were elected for the ensuing year: President, Joseph J. Murphy; Vice-Presidents, E. L. Fetting and A. S. Coleman; Secretary and Treasurer, Robert McKeon.

New England Railroad Club.—At the October meeting, in Boston, the subject for discussion was Steel Tired Wheels, with special reference to equalizing wear, and to machinery for turning up the tires. The discussion was opened by Mr. Lauder, who spoke at considerable length, giving his experience. Messrs. Marden, Snow, Adams, Clarke and others took part in the discussion, the general opinion being that the brake-shoe used made a very great difference in the wear.

Western Railway Club.—At the regular meeting in Chicago, September 16, the subjects of Rigid Center and Swing Beam Trucks for Freight Cars and Flange Wear of Wheels were discussed by members present, a great deal being said on both sides and strong opinions expressed especially in favor of the rigid truck.

The following officers were elected for the ensuing year: President, J. N. Barr; Vice-Presidents, C. A. Schroyer and P. H. Peck; Treasurer, Allen Cooke; Secretary, Walter D. Crosman. A vote of thanks to the retiring officers was passed.

Northwest Railroad Club.—At the regular October meeting in St. Paul, Minn., the first subject for discussion was Brake Beams, upon which a paper was read by Mr. H. L. Preston. This was discussed by members present, who gave their experience at considerable length.

NOTES AND NEWS.

The New German Rifle.—The greater portion of the German Army and Navy has been armed with the new rifle in the course of the last few months, and the issuing of the weapon continues. This is the fifth change of arms made by the German Government in the last 50 years. The new rifle is the design of the Experimental Arms Commission, appointed some time ago, and charged to report a small caliber arm suited to German troops. The report favored a rifle of 7.9 mm. (0.31 in. caliber) of the Männlicher type.

The most interesting feature in the new arm is in connection with the barrel. The commission believed that want of accuracy was often due to irregularity of dilatation. It was, therefore, resolved to free the barrel as much as possible from extraneous matter, such as fittings and aiming apparatus. In the new rifle the barrel is inclosed in a tube on which are fixed the breech and front sights, with a space of a demi-millimeter between the tube and the barrel. The projectile is a mere kernel of hard lead, cylindro-ogival in shape, and having a steel-nickel coating. It weighs 14.5 grams. The cartridge weighs 27.5 grams. Its length is 82.5 mm. (3.25 in.). The magazine with its five cartridges weighs 154 grams. The soldier or blue jacket carries in each cartridge box in front two magazines, with six in the cartridge box behind. He has thus 150 cartridges, representing a weight of 5.030 kilos (11.09 lbs.).

The initial speed of the projectile is 620 meters, and the limit of its range, at an angle of 32°, is 3,000 meters. At 100 meters it passes through a block of deal of 80 cm. thickness, and at 1,800 meters it perforates a plank of this wood 5 cm. in thickness. At 300 meters it passes through an iron plate of 7 mm. At 2,000 meters, after ricochet, it buries itself from 2 to 3 cm. At 200 meters it pierces a cuirasse in its strongest part.

Experiments show that an earthwork parapet cannot afford shelter unless it has a thickness of 0.75 meters at least. Brick walls of small thickness are not absolute proof against the ball; several shots striking the same spot will make a breach. Six haversacks completely charged and placed one behind the other were pierced from end to end by every shot fired at them.

The Cernavoda Bridge.—This bridge, for which the contract was let to the Fives-Lille Company of France, for the sum of $1,527,000, will be the first bridge over the Danube eastward of Neusatz, near the mouth of the river Theiss. Cernavoda, as well as the Black Sea harbor of Kustenji, are situated in the Dobrudsha, the new Roumanian province, and both are connected by a railroad about 40 miles long. The object of the bridge is to continue this railroad westward into Roumania. About 90 ft. below low-water lime-stone rock is found, and the foundations of the piers, whose crown is about 120 ft. above low water, go down to the rock. The bridge—a single-track bridge—consists of five spans: 459, 459, 623, 459, and 459 ft. Spans two and four are girders, 55 ft. 9 in. deep in the center, and 105 ft. over the piers; cantilevers 164 ft. long project beyond the piers into the first, third and fifth spans; there is consequently left in each of these spans an opening of 295 ft., which is bridged over by a semi-parabolic girder 42 ft. 8 in. deep in the middle and 29 ft. 6 in. at the ends. On the two middle piers are fixed bearings, and on the four remaining supports are roller-bearings; a movable bearing is also at one end of the central girder of 295 ft. span.

The principle of the cantilever, as described above, was adopted after various other principles had been proposed, and after it had become evident that a clear headway for navigation of about 100 ft. throughout was required, and that neither a continuous girder nor an arch bridge would have been practicable. The design is by Mr. Saligny, Engineer to the Roumanian Government.

The material for the girders is basic Martin ingot steel, of a tensile strength of from 27 to 30 tons, with 16 to 21 per cent. elongation. The strain per square inch from the load is not to exceed 6.36 tons per square inch, and from load and wind-pressure together 7.64 tons. The wind-pressure is assumed at 50 lbs. per square foot on the bridge without the load, and 37 lbs. on the bridge with the load. The bending strains in some of the long members arising from their own weight amount to 1.2 ton per square inch in the diagonals, and to 1.22 ton in the flanges, and they have been taken account of in determining the sectional areas. Other conditions of strength, and various conditions as to the manipulation of the material, are of interest.

As in the Forth Bridge, the transverse bracing between the top flanges of the cantilever girders is omitted, and this is described as having several advantages. The distance between the cross-girders varies between 42 ft. 8 in. and 23 ft. 8 in., and they are plate-girders with 5.7 tons strain per square inch. The stringers are 7 ft. 10½ in. apart, and upon them an iron trough-flooring is laid. The sleepers, 9½ in. wide and 6 in. deep, lie in the troughs bedded in gravel.

The weight of steel in the superstructure is 3,385 tons; that of the trough-flooring 226 tons, and that of the gravel-packing, sleepers, etc., 325 tons; a total of 3,936 tons in 2,460 feet, or 1.6 tons per foot lineal. The iron caissons will weigh 887 tons. The four piers will contain 1,214,250 cubic feet of stone masonry, and 13,054 cubic yards of concrete.

A Substitute for Forced Draft.—The British Admiralty has made a series of trials to test Martin's system for securing the rapid development of steam without endangering the stability of the boiler, which is a practical reversal of the forced draft system. He proposes to place a fan at the root of the funnel, so that the hot air may be sucked through the tubes instead of being forced through them by the operation of fans in the stokehole. By this means, he contends, the stoking will be rendered less difficult and laborious, and the impinging of the blast upon tube plates will be considerably lessened, if not wholly prevented. The boiler selected for the experiment was one of a locomotive set originally belonging to the *Polyphemus*. The results demonstrate, it is said, that with induced draft, which closely approximates to the railroad system, a marine boiler is capable of steaming at a much higher rate than with forced air, and with perfect safety, and that the maximum power, which is now confined to four hours at the utmost, can be indefinitely continued for the longest voyage. The boiler at the end of the steaming was found to be in such good condition that it is proposed to test it with forced draft.

Superheating Steam.—In describing a visit to Logelbach, the home of M. Hirn, a writer in *Industries* refers to an arrangement for superheating steam in an engine which has been in use for forty years. This plan of M. Hirn's was one of the first put to the test and practically applied, is still always in use, and is considered to give a greater economy of feed water than the steam jacket. The amount of superheating is about 140° Fahr. The superheating apparatus consists of a series of pipes, and is invisible, as it is placed toward the end of the boiler, where the hot gases play constantly over its surface. This method involves no additional expenditure of fuel or labor. The mere fact that the superheating arrangement has been in constant operation for so many years, without more detriment to the valves, gear, etc., than is incidental to any engine when at work, proves that the system is of real practical advantage, and deserves more attention than it has hitherto received.

A Universal Cement.—A cement of universal adaptation, that is readily and permanently adhesive to any substance, has long been a desideratum, and to its realization Professor Alexander Winchell appears to have successfully directed his skill as a chemist. His method is to take two ounces of clear gum arabic, one and one half ounces of fine starch, and one half ounce of white sugar, the gum being then pulverized and dissolved in the same quantity of water as is commonly employed in laundry operations for the quantity of starch indicated, and both starch and sugar are dissolved in the gum solution, the mixture being now suspended in a vessel in boiling water until the starch becomes clear. The cement should be as thick as tar, and remain so, prevention from spoiling being insured by dropping in a lump of gum camphor or a little oil of cloves or sassafras. This cement is so very strong and tenacious that it will hold immovably to glazed surfaces, will repair broken rocks, minerals, and fossils, and has innumerable adaptations in the mechanical and industrial arts.

Quadruple Expansion.—Mr. Robert Carson, of Hull, in writing to a foreign paper, mentions as a practical illustration of the advantages of quadrupling, his own experience with the steamship *European*, trading between the above port and Amsterdam. The old engines, he states, were a good sample of an economical working compound, indicating about 480 I.H.P., the average consumption of coal for all purposes for the voyage out and home being 32 tons. After quadrupling, and replacing the boiler by one of his own special design, the engines indicated 540 H.P., and the consumption of fuel was reduced to 20 tons per voyage for all purposes, thus making a saving of 12 tons per voyage. He accordingly advises the shipowner who is despondent over being the possessor of a steamer the engines of which are becoming obsolete, to quadruple their old engines, and thereby obtain the necessary economy to enable the old vessels to compete with those of more modern type. Another important saving besides the reduced fuel consumption, he mentions, results from the reduction in deadweight carried about continually by the vessel. The boiler, he says, is small; uptake, casings, fittings and water in the boiler reduced, as well as the quantity of bunker coals required for the voyage. This, in the case of the *European*, amounted to as much as 37 tons.

Smoke Prevention.—The Society of German Engineers has arranged to offer two prizes of $720 each for the best papers on smoke prevention, one for steam boilers, and one also for domestic furnaces, with additional prizes of $240 for drawings.

Old Compound Engines.—M. Kraft, Chief Engineer of the Works of the Société John Cockerill, at Seraing, Belgium, has sent us the following note made by him during the recent trip to Russia. On this trip he saw on the Volga River three tow-boats—the *Sampson*, the *Hercules* and the *Volga*—furnished with compound engines, built by Roentgen at the Fijnoord Works, in Rotterdam, Holland. These boats were ordered in 1845 and delivered in 1847, and the frame carries the latter date cast in the iron.

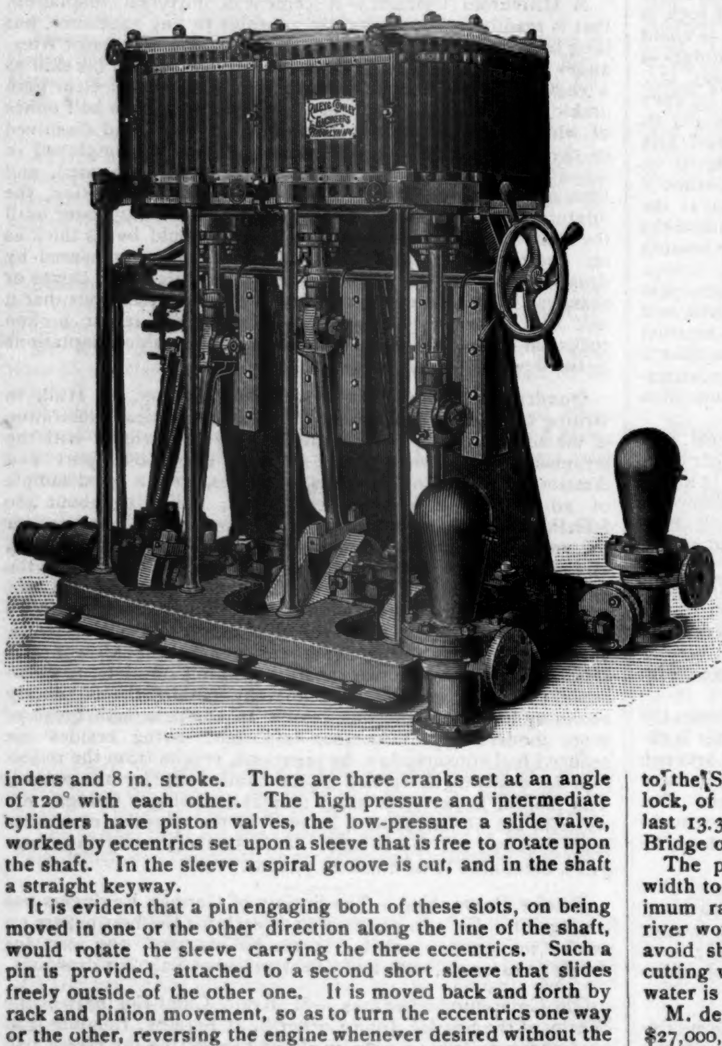
The cylinders are fixed, placed opposite to each other and inclined, with the connecting rods working the same crank. A long steam pipe joins the opposite cylinders, forming an intermediate reservoir, a plan often adopted in later engines. The steam pressure carried was originally 95 lbs., but the boilers have since been changed, and the working pressure at present in use is 120 lbs.

The high-pressure cylinder is 30½ in. in diameter and the low-pressure cylinder 60½ in., the stroke being 7 ft. The cylin ers

are furnished with piston valves. The frame is of wrought-iron plates and angles, with a cast-iron base.

These engines are said to have developed 800 H. P. They have been at work without renewal, with only ordinary repairs, since they were first built, but the boilers originally put in have been replaced by new ones. M. Kraft found on the *Sampson* in April last a chief engineer, originally from the Rhenish provinces, who had run the engines for 30 years.—*Memoires de la Société des Ingenieurs Civils, Paris.*

A Small Triple-Expansion Engine.—The accompanying illustration shows a triple-expansion engine built by Riley & Cowley, of Brooklyn, N. Y., for the steel steam launch *Lillian*, now under construction by the Jonson Foundry & Machine Company, New York. The *Lillian* is 65 ft. long, and is driven by a screw 31 in. in diameter and 48 in. pitch. The engine is characterized by simplicity of construction and accessibility of parts, and from these features may be considered as peculiarly adapted to service of this nature. As the cut shows, the slides and moving parts are readily accessible from the starboard side. It is a triple-expansion engine, with 4-in., 6½-in. and 10-in. cylinders and 8 in. stroke. There are three cranks set at an angle of 120° with each other. The high pressure and intermediate cylinders have piston valves, the low-pressure a slide valve, worked by eccentrics set upon a sleeve that is free to rotate upon the shaft. In the sleeve a spiral groove is cut, and in the shaft a straight keyway.



It is evident that a pin engaging both of these slots, on being moved in one or the other direction along the line of the shaft, would rotate the sleeve carrying the three eccentrics. Such a pin is provided, attached to a second short sleeve that slides freely outside of the other one. It is moved back and forth by rack and pinion movement, so as to turn the eccentrics one way or the other, reversing the engine whenever desired without the use of the complication involved in ordinary link motion.

The estimated H.P. is placed at 75, giving 450 revolutions with a steam pressure of 160 lbs. to the square inch. There are independent air, circulating and feed pumps. The surface condenser contains 120 square feet of cooling surface.—*American Shipbuilder.*

Aluminum in Alloys.—In his address as President of the British Association for the Advancement of Science, Sir F. A. Abel recently made the following remarks:

"It appears to be already established that the modifications in some of the physical properties of steel resulting from the addition of aluminum are not merely ascribable to its actual entrance into the composition of the steel, but are due, in part, to the deoxidation by aluminum of some proportion of iron oxide which exists distributed through the metal, and prejudicially affects its fluidity when melted. In the latter respect, therefore, the influence exerted by aluminum, when introduced in small proportions into malleable iron and steel, appears to be quite analogous to that of the phosphorus, silicon, or lead when these are added in smaller proportions to copper and certain of its alloys, the deoxidation of which, through the agency of those substances, results in the production of sound castings of increased strength and uniformity. It is only when present in small proportion, in the finished steel, that aluminum increases the breaking strain and elastic limit of the product. The influence of aluminum, when used in small proportion, upon the properties of gray and white cast-iron, is also of considerable interest, especially its effect in promoting the production of sound castings, and of modifying the character of white iron in a similar manner to silicon, causing the carbon to be separated in the graphite form; with this difference, that the carbon appears to be held in solution until the moment of setting of the liquid metal, when it is instantaneously liberated, with the result that the structure of the cast metal and distribution of the graphite are perfectly uniform throughout. . . .

"At the celebrated French Steel Works of M. Schneider, at Creuzot, the addition of a small percentage of copper to steel used for armor-plates and projectiles is practised, with the object of imparting hardness to the metal without prejudice to its toughness. James Riley has found that the presence of aluminum in very small quantities facilitates the union of steel with a small proportion of copper, and that the latter increases the strength, but does not improve the working qualities of steel. With nickel, Riley has obtained products analogous in many important respects to manganese steel; the remarkable differences in the physical properties of the manganese alloys, according to their richness in that metal, are also shared by the nickel alloys, some of these being possessed of very valuable properties; thus, it has been shown by Riley that a particular variety of nickel steel presents to the engineer the means of nearly doubling boiler-pressures, without increasing weight or dimensions. He has, moreover, found the co-existence of manganese in small quantity with nickel in the alloy to contribute importantly to the development of the valuable physical properties."

A Ship Canal to Paris.—A plan has been prepared by M. Bouquet de la Grye, a distinguished French engineer, for making Paris accessible to ships of considerable size. The improvements now in progress in the lower Seine will give a depth of 20.34 ft. of water up to Rouen, and M. de la Grye proposes to convert the river from that point up to Paris into a ship canal. This would be divided into five levels by four locks. The first would extend from Rouen to Poses, 14.31 miles, where a lock of 20.7 ft. lift would begin the Vernon level. This would extend to Mericourt, at which place a lock of 22 ft. lift would begin the Poissy level, 26.97 miles long, to Poissy, where a third lock of 13.87 ft. lift would rise to the Sartrouville level, 11 miles long, running to the fourth lock, of 10.5 ft. lift, which would begin the St. Denis level, the last 13.34 miles in length, the end of the canal being at the Bridge of Clichy, in Paris.

The plan is for a uniform depth of 20.34 ft. of water, the width to be 115 ft. on tangents and 148 ft. on curves; the minimum radius of curvature to be 5,000 ft. The course of the river would be followed, with only a few necessary changes to avoid sharp bends, except at Oissel and Besons, where some cutting would be done to avoid draw-bridges. The supply of water is said to be abundant.

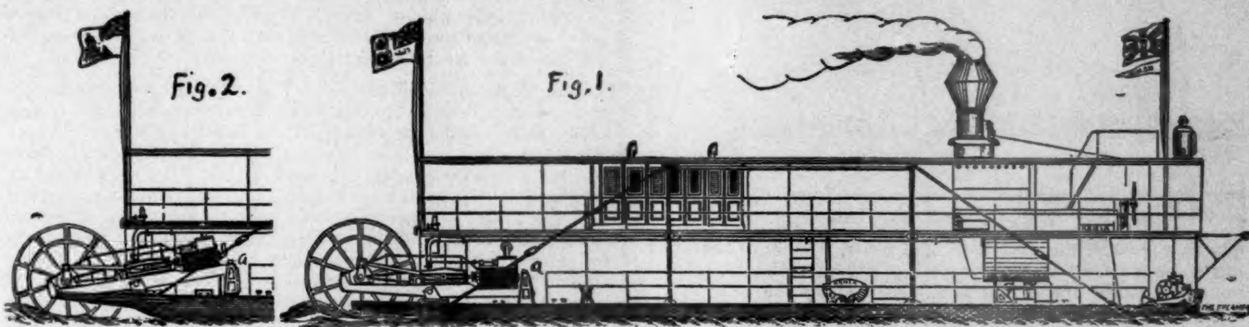
M. de la Grye estimates the cost of the proposed work at $27,000,000; the time required for the execution of the necessary works would be about three years. The commercial advantages, it is claimed, would be very great, as Paris would be made practically a seaport.

Painting.—It is found that in painting wood one coat takes 20 lbs. of lead and 4 gals. of oil per 100 sq. yds.; the second coat, 40 lbs. lead and 4 gals. of oil, and the third the same as the second, say 100 lbs. of lead and 16 gals. of oil per 100 sq. yds. for the three coats. The number of square yards covered by one gallon of priming color is found to be 50; of white zinc, 50; of white lead paint, 44; of lead color, 50; of black paint, 50; of stone color, 44; of yellow paint, 44; of blue color, 45; of green paint, 45.

A New Stern-Wheel Steamboat.—The accompanying illustration—from the *Steamship*—shows the stern-wheel steamboat *Kenia*, built by Kincaid & Company, Greenock, Scotland,

for use on the Tana River in East Africa. The *Kenia* has a steel hull, is 80 ft. long and 21 ft. broad, and has a draft of 18 in. light and 39 in. when fully loaded. The engines are compound, and use steam at 120 lbs.

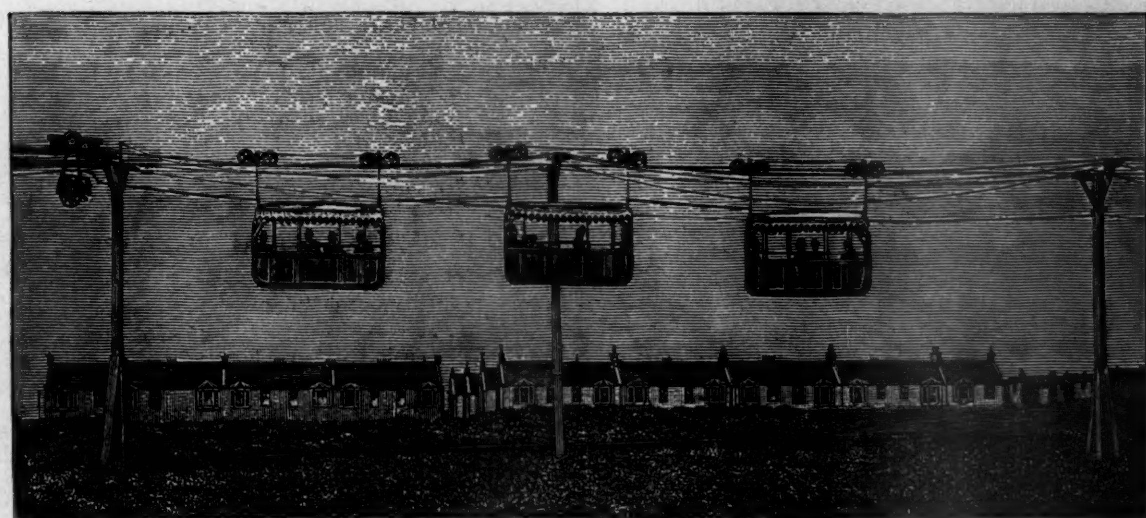
The peculiarity of the boat is the arrangement by which the wheel can be adjusted at the best depth, no matter what the draft; this is patented by Mr. Kincaid, in England. In the illustrations fig. 1 shows the boat loaded down to her greatest draft, while fig. 2 shows the stern when running light. As will be seen, the engines and the wheel are mounted on a frame which is carried on trunnions near the center, and which can be adjusted at any angle, within a sufficient range, by means of the



standard frame *a*. The weights are so nearly balanced that only a very small force need be applied to alter the angle of the frame. In this way the wheel can be kept immersed to about the same depth, no matter what the draft may be. The arrangement seems to be a very convenient one for a small boat.

A Diminutive Electric Light and Power Station.—Collias, near Nîmes, a village of 465 inhabitants, has just been lighted by electricity. The motive power for the 1,600-light dynamo is derived from a small waterfall. The streets are lighted by 25 lamps of 16 candle-power each. Besides lighting the village, the current is employed during the day in putting in motion the pumps for supplying certain parts of the village with water.

The Telpher Line at Edinburgh.—The Telpher line put up at the Edinburgh Exhibition by the Electrical Engineering Corporation shows the most recent improvements, and is arranged so as to carry passengers as well as demonstrate the advantages of the system for this transport of goods.

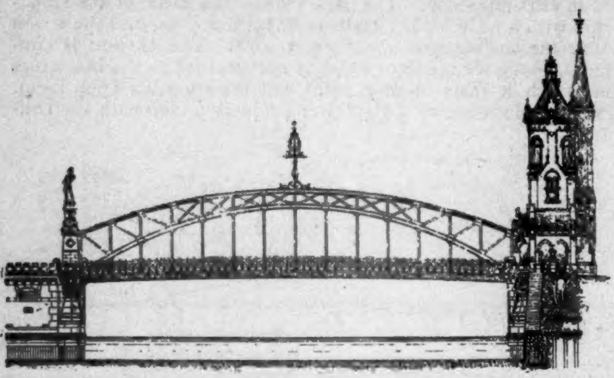


The Edinburgh line consists of over a quarter mile of track, the flexible portion of it being constructed in spans of 50 ft. and the rigid ends in spans of 15 ft. The stand-ropes on which the locomotive and carriages travel are of crucible steel and $1\frac{1}{8}$ in. in diameter. These are tightened, so that with a full load on the line there is a sag of about 2 ft. $4\frac{1}{2}$ in. on the spans covered by the train. The arms supporting the stand-rope are arranged so that they move in either direction, allowing the sag in the rope to follow the train as it moves along, thus not putting any undue strain upon the posts themselves. The stand-rope at its junction with the rigid rail passes from a special descent junction saddle so arranged that the train rises from the rope on to the rigid rail without any jerk or other unsatisfactory movement. From the junction saddle the stand-rope passes direct to a structure termed the abutment post; this is fastened to the substantial anchorages in the ground by flexible steel ropes 5 in. in circumference. The strain upon the ends of the stand-rope with a fully loaded train is about five tons, and the strain upon the anchorages about eight tons. The current is conducted along a conductor which is not attached to the insulators on which it rests at any point, but merely rests upon them. From the locomotive a rigid arm projects underneath the conductor, but above the insulators, and slides along under the conductor, lifting it off the insulators as the arm passes them, allowing it to rest on them again after it has passed.

The train, as will be seen from the illustration, is a very practicable one; the cars, which with the plant and the rest of the equipment were made at the works of the Electrical Engineering Corporation at West Drayton, are built much in the fashion of railroad carriages, each car having two compartments and holding four persons, and each compartment being entered from a door with a latch. The whole of the car is suspended by iron hangers from two trucks, the bodies of which latter consist of mitis iron castings resting on the axles of the wheels at each end. The hanger does not depend directly from the body of the truck, but rests upon two vertical springs contained in boxes on each side of the body.

The locomotive consists of what is termed by the builders a swinging tub, and the motor drives a small countershaft, to one end of which is attached an electrical governor to maintain a set speed; the other end of the countershaft has upon it a chain-wheel, which drives directly upon a larger chain-wheel contained on the upper frame. The motor is suspended from the upper frame by a hanger, so arranged as to allow the whole to swing, the swinging movement thus allowed not interfering with the motion of the chain, as it is a movement radially to the center of the large chain-wheel on the upper frame. The upper frame contains, in addition to the large chain-wheel, two driving-wheels with malleable cast iron tires to grip the rope, each attached to a chain-wheel driven from the shaft supporting the large central chain-wheel.—*London Electrician.*

A German Bridge.—The accompanying cut represents a bridge recently erected to carry a street over the Zoll-canal in Hamburg, Germany. It presents no special features of construction, but is notable for its neatness and elegance of design. It is obviously a bridge; that could not well be concealed, but the general effect on the eye is good enough to satisfy even our



exacting friends, the architects and poets, who have been finding so much fault with engineering structures lately, and denouncing engineers as Vandals who destroy the beauty of a landscape.

A French Fast Train.—A new locomotive built in the shops of the Northern Railroad has just been tried at high speed, with a special train of 16 carriages, having a total weight of 667,800 lbs. Lead bars were put in the carriages to represent the average weight of passengers, baggage, etc., carried on an express train.

This train ran from Paris to Calais by the direct line, a distance of 184.56 miles, in 3 hours, 53 minutes; two stops were made, one of five minutes at Amiens, the other of two minutes at Abbeville. The average speed, making no allowance for stops, was thus 47.53 miles an hour. The run from Paris to Amiens was made at the rate of 51.58 miles an hour, the train going up the Survilliers grade—0.5 per cent, 11.19 miles long—at the rate of 46.6 miles an hour.

On the return trip another carriage was added, making 17 in all. From Calais to Lille the average speed was 49.7 miles an hour, the highest speed 59 miles. Between Lille and Paris the average speed was about the same, but a speed of 71.46 miles an hour was reached in going down the Survilliers grade.

The Suez Canal.—The number of vessels passing through the Suez Canal at night by means of electric light is increasing with extraordinary rapidity. The regulations for the use of the electric light came into operation in March, 1887, and during the remainder of that year (according to statistics given in the recent British Consular report from Port Said) the number using it was 394. In 1888 the number rose to 1,611, and last year reached 2,445. Prior to March, 1887, the privilege of traveling by night with electric light had been restricted to vessels carrying the mails; since then all ships which conform to the regulations are allowed to proceed by night. The average time of transit has also been considerably shortened. In 1886 it was 36 hours; in 1887, 33 hours and 58 minutes; in 1888, 31 hours and 15 minutes; and in 1889 it had been reduced to 25 hours, 50 minutes. The average time for vessels using the electric light in 1889 was 22½ hours. The shortest time taken by a steamer in the transit of the canal in 1889 was 14¾ hours, which is 10 minutes less than the fastest passage on record previously.—*Nautical Magazine.*

The Baltimore & Ohio Relief Department.—The annual report of the Relief Department of the Baltimore & Ohio Railroad Company, which is the successor of the old Relief Association, states that out of 20,626 members of the Association, 19,089 voluntarily became members of the Department. During the fiscal year 1889, benefits were paid to 10,922 persons the total amount being 296,103. These payments included 79 for death from accident; 3,442 for accidental injuries; 139 for deaths from natural causes; 4,929 for sickness, and 2,333 for surgical expenses. At the close of the year there were 19,894 members.

The pension feature shows that during the year $24,160 were paid to pensioners, of whom the total number on the list at the end of the year was 157.

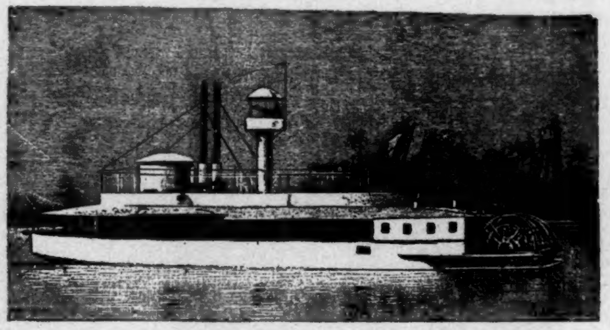
The savings feature shows total deposits of $435,553, the amounts received during the year being $149,576. The total amount loaned to employés since this feature was instituted has been expended in building 332 houses, buying 311 houses, improving 76 houses already owned and releasing liens in 169 cases.

Developing Alabama Ore-Beds.—The New South Mining & Manufacturing Company is now constructing a line known as the Tennessee River, Ashville & Coosa Railroad, which will extend from Decatur, Ala., to Lock No. 3 on the Coosa River, a distance of 100 miles. It crosses the Alabama Great Southern at Whitney, 102 miles from Chattanooga, and at Lock No. 3 connects with water navigation on the Coosa and with the East & West Railroad of Alabama. The road is built chiefly to reach the mineral deposits on the line, which include coal, limestone and iron ore of fine quality, both red and brown ore; there is also much good timber.

This is only one of several enterprises which show to how great an extent the southern mineral deposits are attracting attention in the North and elsewhere.

The Portelectric Railroad.—The so-called portelectric system, which was on exhibition in Baltimore not long ago, is now being tried in the neighborhood of Boston, where an experimental line 3,000 ft. long, in which are introduced several sharp curves and heavy grades, has been built. This system, which is intended to transmit packages, mail and similar matters at very high rates of speed, consists of a long car, shaped something like a cigar, running on a single rail, and kept in place by an upper guide. On the experimental road the car is 12 ft. long and 10 in. in diameter and weighs 350 lbs. The road is carried on posts and at intervals are placed coils of wire forming a series of rings through which the car passes, the track forming one part of the electric circuit and the wire in the coils the other. The electricity is generated by a dynamo placed in a power-house on the line. The principle of the road is that the car constitutes a magnet which is attracted or drawn forward by the coils of wire on the line, the apparatus being so made that the section of each coil draws the car within it, but just before it reaches the center by automatic action, the current is cut off. The motion of the car, however, continues, carrying it within reach of the attractive force of the next coil. The Boston projectors have much faith in this system, and believe that it can be applied advantageously for carrying mails and express matter between cities, and that a very high rate of speed can be attained.

A French River Gun-boat.—The accompanying illustration, from *Le Yacht*, shows the gun-boat *Berthe-de-Villers*, built for the French Navy, for special river service in Tonquin. It is a flat-bottomed boat modeled somewhat on American lines, and



propelled by a paddle-wheel at the stern, driven by two horizontal engines of ordinary pattern. The hull is of iron, and some protection is given to the crew and machinery by the bulwarks and shields, which are proof against rifle shots at ordinary ranges.

The boat carries several machine guns, one of which is mounted in the top, as shown in the picture, giving it a considerable range. While not of service against artillery of any weight, this gun-boat is strong enough to be formidable in forest or savage warfare, of the kind for which she is designed.

The Hudson River Bridge Company.—This company, which is to build a bridge over the Hudson at New York on the plans of Mr. Lindenthal, has been organized, with the following officers: President, Jordan L. Mott, New York; Secretary, M. H. Houseman; Treasurer, Charles J. Canda; Counsel, Charles F. McLean; Chief Engineer, Gustav Lindenthal. Other directors are: James Adams, Thomas F. Ryan, William Brookfield, New York; Edward F. C. Young, Jersey City, N. J.; John K. McLanahan, Hollidaysburg, Pa. The company is incorporated under acts of Congress and the Legislatures of New York and New Jersey.